UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Computational Biology and Complex Systems Research Group

CMCiB Comparative Medicine & Bioimage Centre of Catalonia

IGTP Germans Trias i Pujol Research Institute

Daily report 29-06-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Situation report 95

Contact: clara.prats@upc.edu

With the financial support of: MINISTERIO DE CIENCIA E INNOVACIÓN "la Caixa"

Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ *a*: the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ *K*: the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to data-points. We also discuss a specific issue every day.

Martí Català
Pere-Joan Cardona, PhD
Comparative Medicine and Bioimage Centre of Catalonia; Institute for Health Science Research Germans Trias i Pujol

Clara Prats, PhD
Sergio Alonso, PhD
Enric Álvarez, PhD
Miquel Marchena
David Conesa
Daniel López, PhD
Computational Biology and Complex Systems; Universitat Politècnica de Catalunya - BarcelonaTech

With the collaboration of: Guillem Álvarez, Oriol Bertomeu, Laura Dot, Lavínia Hriscu, Helena Kirchner, Daniel Molinuevo, Pablo Palacios, Sergi Pradas, David Rovira, Xavier Simó, Tomás Urdiales

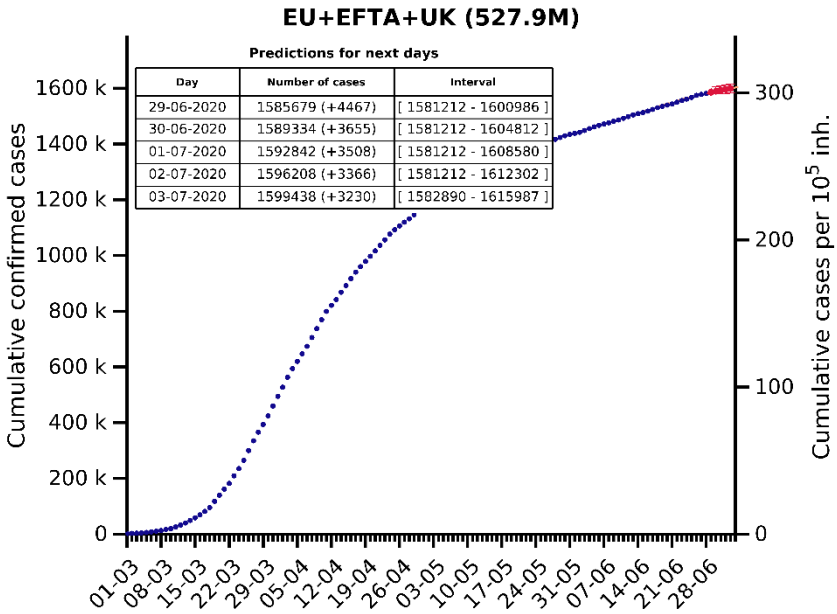
PJC and MC received funding from "la Caixa" Foundation (ID 100010434), under agreement LCF/PR/GN17/50300003; CP, DL, SA, MC, received funding from Ministerio de Ciencia, Innovación y Universidades and FEDER, with the project PGC2018-095456-B-I00;

Disclaimer: These reports have been written by declared authors, who fully assume their content. They are submitted daily to the European Commission, but this body does not necessarily share their analyses, discussions and conclusions.

(0) Executive summary – Dashboard

Situation and highlights

UE+EFTA+UK starts a new week with an empiric reproduction number slightly above 1. Last days, there are appearing several (hopefully) local outbreaks all around the continent, most of them being properly detected and controlled by means of the test and trace strategy, but that could be reflecting a worrying situation in some cases.



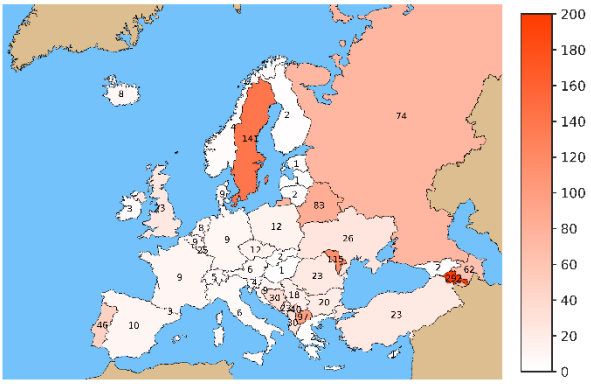
We must recall the usefulness of risk diagrams on analysing secondary outbreaks: green and yelloy zones mean that contagion chains can be followed, on average, case by case. Red zone implies that test and trace is not enough for controlling transmission chains, and that stronger control measures should be considered. Then, we see that last days' increases in new cases in **Luxemburg**, **Croatia**, **Czech Republic**, **Romania** and **Bulgaria** situate those countries close to or at the yellow zone. **Portugal** is still stuck at the yellow zone. The increase in daily new cases has been controlled, but this value is still not going down again. **Germany** could be controlling last week outbreaks, since its empirical reproductive number crosses again the control thershold (ρ_7=0.9).

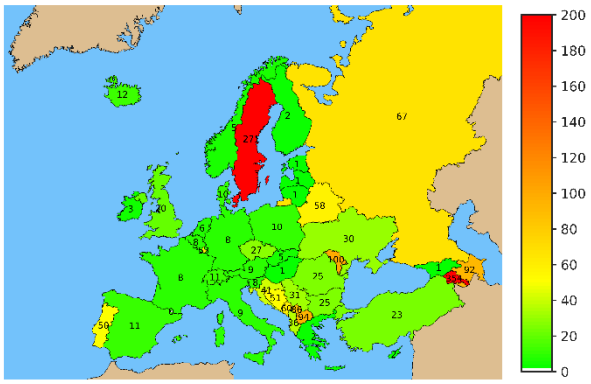
Switzerland and **Austria**, two countries that have been leaders in Europe on controlling the first wave, are now showing signs of local outbreaks, but both at the green zone ($\rho_7 \approx 2$ and 1.3, respectively). Looking at the Biocom-Cov scale, which assign a 1 to 9 degree according to the mean daily new cases, both countries have increased from level 2 (last week) to 3 (this week). Even Iceland, which remained with 0 or 1 daily new case for the last 2 months, is now reporting 3 or 4 daily.

In all cases, it must be stressed that new cases are not necessarily spread along the country, but that in most of countries correspond to local outbreaks, as mentioned. Therefore, in relative terms, the situation in the corresponding regions can be really worse.

Data from Sweden, France and Denmark present some gaps. Therefore, the different indicators and risk indexes are not reliable.

The map in the left shows current **A_{14}**. The map in the right shows current **EPG**.





Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. Last column (**EPG_{EST}**) is assessed with **estimated real 14-day attack rate** (see report from 22/04 for details). **EPG_{REP}** is calculated with **data reported by countries**. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [1]	EPG_{REP} [2]	EPG_{EST} [3]	Biocom-Cov degree
United Kingdom	311,151	468.3	43,550	65.5	15,262	23.0	218,780	322.3	0.87	20	280	3
Spain	248,770	536.7	28,343	61.2	4,842	10.4	56,303	119.7	1.13	12	136	3
Italy	240,310	404.4	34,738	58.5	3,321	5.6	48,526	80.3	1.56	9	125	2
Germany	193,761	236.5	8,961	10.9	7,300	8.9	34,785	41.5	0.93	8	39	2
France	162,936	251.8	29,778	46.0	5,716	8.8	107,466	164.6	0.96	8	157	2
Sweden	65,137	662.1	5,280	53.7	13,523	137.5	114,673	1,135.5	2.03	278	2,300	8
Belgium	61,361	540.2	9,732	85.7	1,219	10.7	18,834	162.5	0.76	8	124	3
Netherlands	50,147	295.2	6,105	35.9	1,364	8.0	17,055	99.5	0.81	7	81	2
Portugal	41,646	401.5	1,564	15.1	4,956	47.8	19,527	191.5	1.02	49	196	6
Poland	33,907	88.7	1,438	3.8	4,515	11.8	19,770	52.2	0.86	10	45	3
Switzerland	31,534	368.0	1,681	19.6	500	5.8	2,726	31.5	1.99	12	63	3
Romania	26,313	133.0	1,612	8.2	4,314	21.8	28,932	150.4	1.11	24	166	4
Ireland	25,439	538.3	1,735	36.7	136	2.9	931	18.9	1.11	3	21	2
Austria	17,625	202.3	702	8.1	587	6.7	2,406	26.7	1.31	9	35	2
Denmark	12,675	221.9	604	10.6	482	8.4	2,352	40.6	1.21	10	49	2
Czech Republic	11,603	109.3	348	3.3	1,579	14.9	5,394	50.4	1.83	27	92	4
Norway	8,815	164.2	249	4.6	209	3.9	579	10.7	1.29	5	14	2
Finland	7,191	130.7	328	6.0	87	1.6	421	7.6	1.37	2	10	2
Bulgaria	4,691	65.8	219	3.1	1,401	19.6	8,313	119.6	1.23	24	147	4
Luxembourg	4,242	736.5	110	19.1	172	29.9	468	74.8	1.91	57	143	5
Hungary	4,142	42.5	581	6.0	66	0.7	992	10.3	2.05	1	21	1
Greece	3,376	30.2	191	1.7	255	2.3	1,485	14.2	0.80	2	11	2
Croatia	2,691	63.9	107	2.5	439	10.4	2,057	50.1	3.83	40	192	3
Estonia	1,987	151.4	69	5.3	14	1.1	NA	NA	1.08	1	NA	1
Iceland	1,838	504.6	10	2.7	28	7.7	NA	NA	1.44	11	NA	3
Lithuania	1,816	62.4	78	2.7	48	1.7	NA	NA	0.70	1	NA	1
Slovakia	1,664	30.6	28	0.5	116	2.1	NA	NA	2.15	5	NA	2
Slovenia	1,581	76.1	111	5.3	86	4.1	634	30.5	1.99	8	61	2
Latvia	1,116	56.6	30	1.5	19	1.0	NA	NA	1.35	1	NA	1
Cyprus	994	85.0	19	1.6	11	0.9	NA	NA	2.70	3	NA	1
Malta	670	156.2	9	2.1	22	5.1	NA	NA	NA	NA	NA	2
Liechtenstein	83	215.3	1	2.6	0	0.0	NA	NA	NA	NA	NA	0
Scale												
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100	1000	
	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0	0	

Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher)

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG_{REP} is the product of attack-rate of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). EPG_{EST} is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and ρ_7. Biocom-Cov degree is an epidemiological situation scale based on the level of last week's mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

Analysis: An update of the percentage of COVID-19 cases diagnosed in European countries.

The assessment of the percentage of cases diagnosed in a country is important so that the real magnitude of the epidemic can be inferred. Our group developed a methodology for determining this percentage[1], based on the assumption of a 1% lethality and taking into account the delays between onset of symptoms, diagnosis, recording, and death (if so).

In our Report #40[(2)], we analyzed the evolution of the diagnostic rate in several European countries. During the first stages of the epidemic, the diagnostic rate remained quite constant in many countries. Therefore, we used to analyze globally the cumulative cases and cumulative deaths in the process of estimating these percentages. Nevertheless, the general improvement of the epidemic situation and the possibility of implementing test and trace strategies have increased the diagnosis capacity in several countries. Today, we present an updated evaluation of the percentage of cases diagnosed with a slight change in the methodology: **we assess the diagnostic percentage at a certain date by looking at the reported cases and deaths of the last month**.

This modification of the methodology entails a consequence: we cannot properly evaluate the diagnosis delay because these short data series do not include enough points. Therefore, we assume a mean delay in diagnosis of 7 days (i.e., mean delay between diagnosis and death, if so, of 11 days). Then, the percentage of cases diagnosed are evaluated as follows:

$$\%\ diagnosis = \frac{lethality}{CFR\ last\ month} = \frac{1\%}{\frac{deaths(t) - deaths(t-30)}{cases(t-11) - cases(t-30-11)}}$$

As seen, the lethality is still fixed at 1%. This value should be revised next month, as soon as the results of generalized serological screenings are analyzed. In some countries, it seems that mortality could have been reduced. Actually, in our general assessments, we consider that low penetration of the virus leads to a lower lethality, as it has been observed in the evolution of the CFR in South Korea. We estimate that low activity of the virus in Europe could lead to a lethality around 0.7%. This observation could be related with the fact that the percentage of young people among confirmed cases has increased, and this collective shows much less mortality. Nevertheless, and given that no conclusive results are still available, we have kept the same hypotheses as last months.

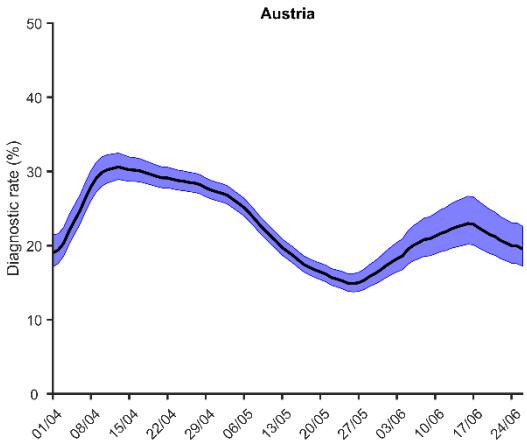
The next table shows the diagnostic rate (DR) in European countries on 29th March, 29th April, 29th May, and 29th June, as well as the increasing or decreasing trend when comparing two consecutive months and the overall trend. We have discarded some countries when we observed either a strong inconsistency in the death data series (e.g., a significant decrease in cumulative deaths at some point) or a too low value of cumulative deaths (i.e., low reliability of evaluation).

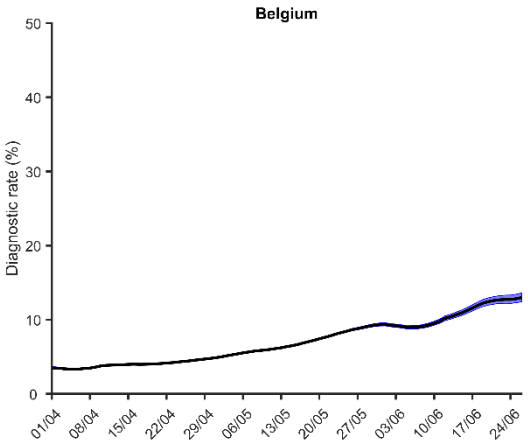
[1] https://www.medrxiv.org/content/10.1101/2020.05.01.20087023v1
[2] https://upcommons.upc.edu/handle/2117/184991

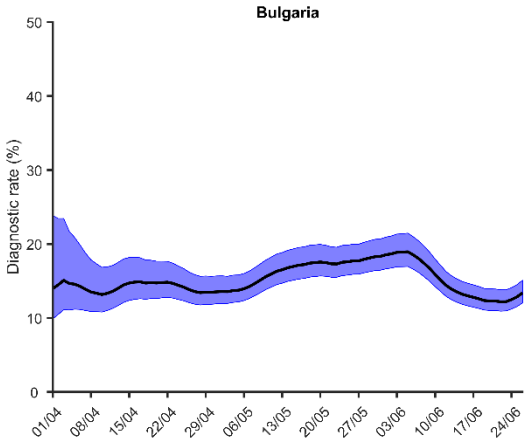
	March DR	April DR	March-April trend	May DR	April-May trend	June DR	May-June trend	Overall trend (March-June)
Austria	17%	28%	11%	16%	-12%	21%	5%	4%
Belgium	3%	5%	2%	9%	4%	13%	4%	10%
Bulgaria	12%	13%	2%	18%	5%	15%	-4%	3%
Denmark	22%	15%	-6%	28%	12%	36%	8%	14%
France	3%	5%	1%	7%	2%	13%	6%	9%
Germany	19%	23%	4%	17%	-7%	23%	6%	4%
Greece	11%	18%	7%	15%	-3%	19%	4%	8%
Hungary	3%	6%	3%	8%	2%	8%	0%	5%
Ireland	10%	12%	2%	19%	7%	14%	-5%	4%
Italy	3%	8%	5%	9%	1%	8%	-1%	5%
Netherlands	3%	7%	4%	11%	4%	21%	11%	19%
Poland	9%	14%	5%	21%	6%	30%	9%	21%
Portugal	4%	21%	17%	25%	4%	40%	15%	35%
Romania	8%	12%	4%	15%	3%	15%	0%	7%
Sweden	16%	5%	-11%	9%	4%	21%	12%	5%
Switzerland	12%	21%	9%	14%	-7%	18%	4%	6%
United Kingdom	1%	4%	3%	10%	6%	10%	0%	9%
EU+EFTA+UK	**4%**	**8%**	**4%**	**11%**	**3%**	**14%**	**3%**	**10%**

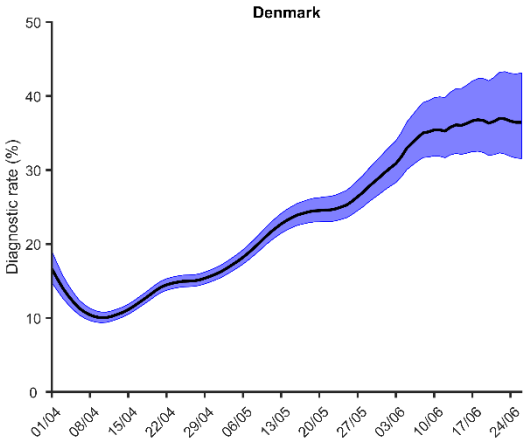
We see that **the general trend is an increase in the diagnostic rate**. Overall, EU+EFTA+UK countries have shift from an initial percentage below 5% up to a 14%. Highest increase would correspond to Portugal, whose DR has increased from an initial 4% to a current 40 %. Poland has followed a similar trend (9% to 30%), as well as Netherlands (3% to 21%) and Denmark (22% to 36%). Countries like Austria and Germany have maintained the initial high DR, at the level of 20%.

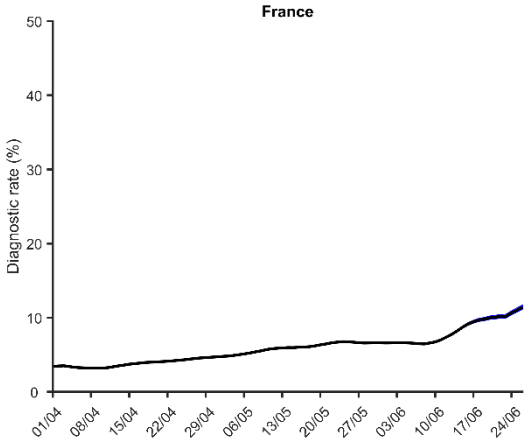
Next, we present a set of figures showing the whole evolution of the diagnostic rate for these countries. Shadowed areas represent the degree of uncertainty, which is determined by applying a binomial to the 1% lethality (i.e., the probability of dying is a binomial with probability 0.01). The results of Belgium have to be considered with caution, since this country reports both confirmed and suspicious deaths by Covid-19, while most of the countries only report deaths with a confirmation. Therefore, the **Belgian diagnostic rate is underestimated**. The final figures show the global diagnostic rate for the EU+EFTA+UK countries.

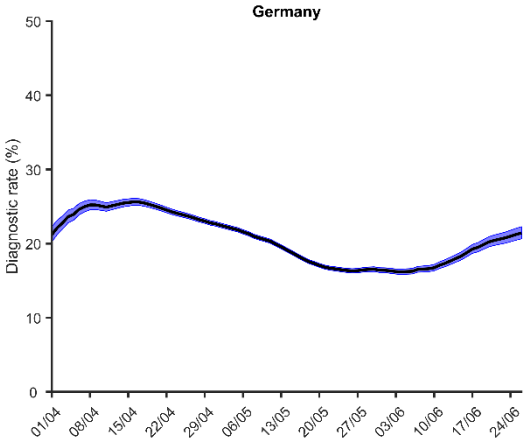


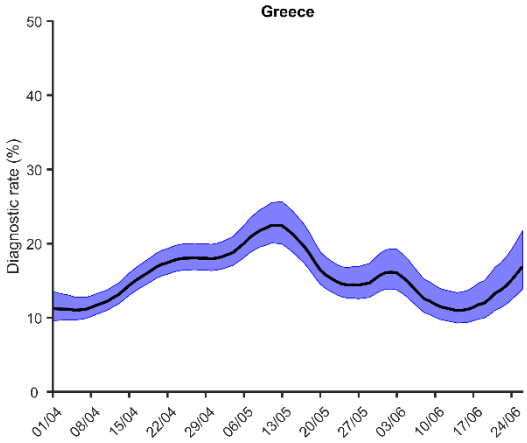


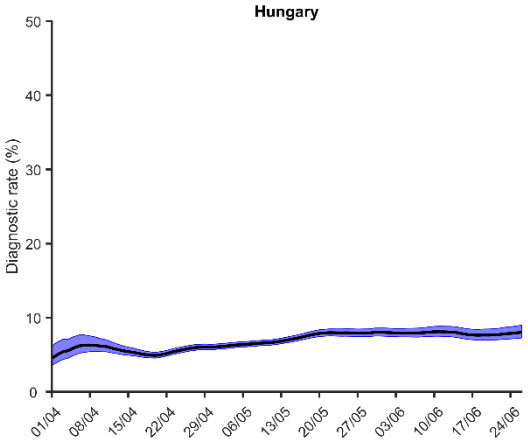

Bulgaria
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

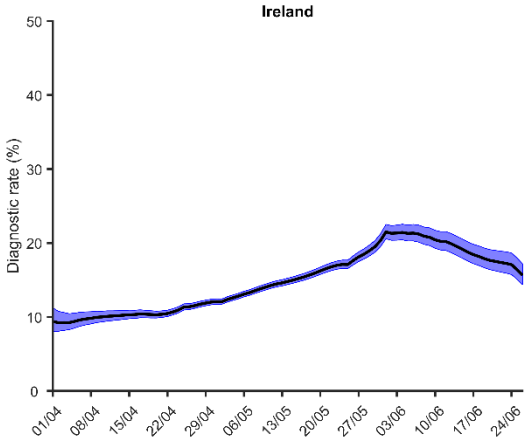

Denmark
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

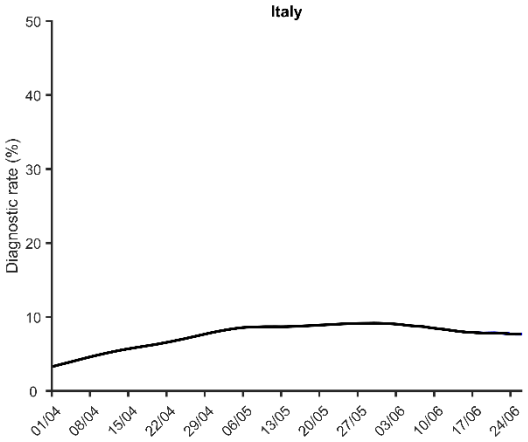

France
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

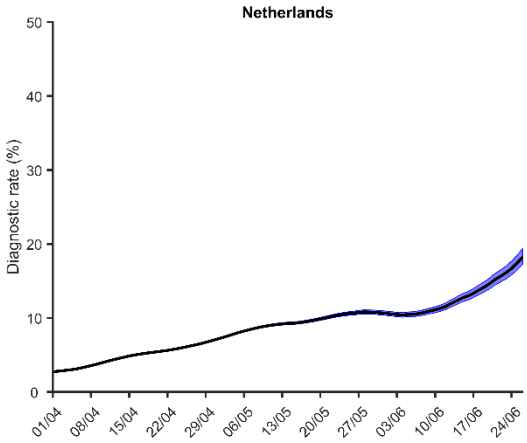

Germany
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

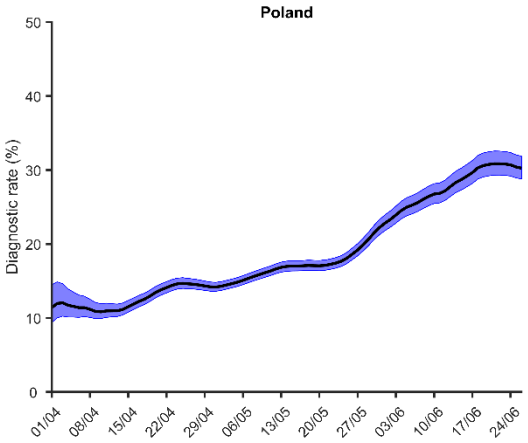

Greece
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

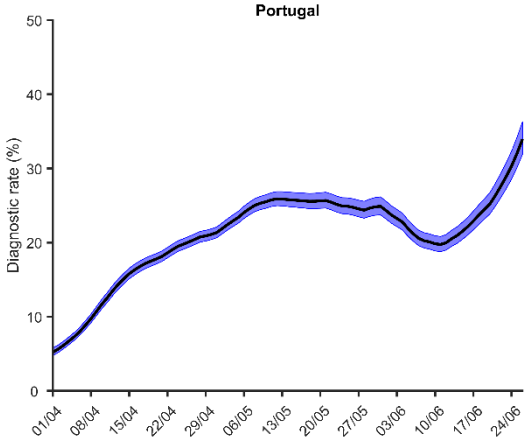

Hungary
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

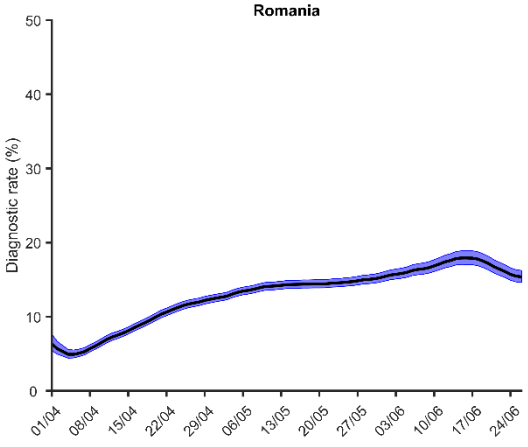

Ireland
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

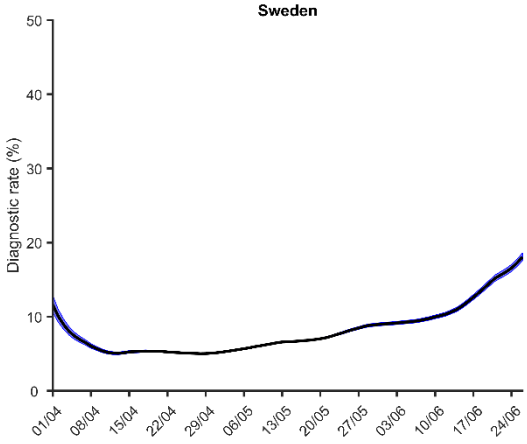

Italy
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

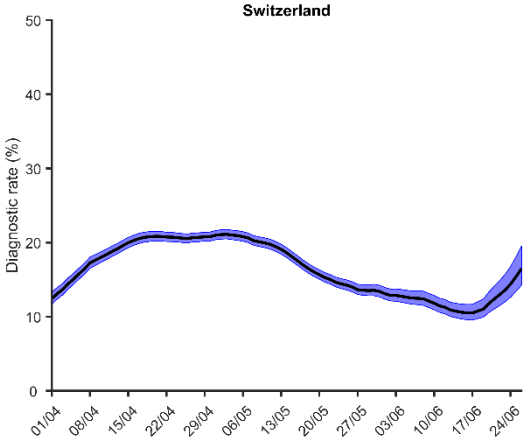

Netherlands
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

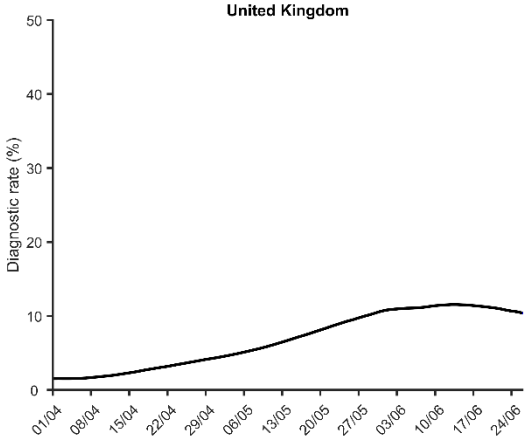

Poland
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

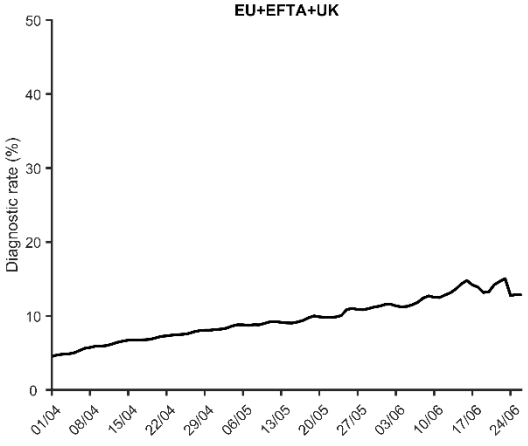

Portugal
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06


Romania
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06


Sweden
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06


Switzerland
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06


United Kingdom
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06


EU+EFTA+UK
Diagnostic rate (%)
0
10
20
30
40
50
01/04
08/04
15/04
22/04
29/04
06/05
13/05
20/05
27/05
03/06
10/06
17/06
24/06

Situation and trends in other countries

Table of current situation in a sample of non-EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [1]	EPG_{REP} [2]	EPG_{EST} [3]	Biocom-Cov degree
United States of America	2.548.996	770,1	125.804	38,0	454.927	137,4	2.400.793	725,3	1,29	178	938	8
Brazil	1.344.143	632,4	57.622	27,1	476.519	224,2	2.299.956	1.082,0	1,16	260	1.256	9
Russia	634.437	434,7	9.073	6,2	105.473	72,3	NA	NA	0,92	67	NA	6
India	548.318	40,5	16.475	1,2	215.894	16,0	837.411	61,9	1,22	19	75	3
Peru	279.419	847,4	9.317	28,3	49.683	150,7	178.998	542,9	1,07	162	584	8
Chile	271.982	1.422,8	5.509	28,8	97.689	511,0	234.221	1.225,2	0,59	304	728	9
Iran	222.669	265,1	10.508	12,5	35.242	42,0	174.203	207,4	1,00	42	208	5
Mexico	216.852	168,2	26.648	20,7	70.015	54,3	1.035.199	802,9	1,07	58	857	6
Pakistan	206.512	93,5	4.167	1,9	62.034	28,1	134.914	61,1	0,74	21	45	4
Saudi Arabia	182.493	524,2	1.551	4,5	54.952	157,8	56.633	162,7	0,87	137	141	8
Canada	103.239	273,5	8.522	22,6	4.463	11,8	38.103	101,0	0,80	10	81	3
Qatar	94.413	3.277,0	110	3,8	14.811	514,1	NA	NA	0,95	488	NA	9
Belarus	61.475	650,6	383	4,1	7.502	79,4	NA	NA	0,73	58	NA	6
Argentina	57.731	127,7	1.217	2,7	26.167	57,9	81.656	180,7	1,32	77	239	6
Ecuador	55.255	313,2	4.429	25,1	8.504	48,2	78.108	442,7	1,30	63	576	6
	Scale											
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	100	1000	
	Best	Best	Best	Best	Best	Best	Best	Best	0,0	0	0	

Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG_{REP} is the product of attack-rate of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). EPG_{EST} is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and ρ_7. Biocom-Cov degree is an epidemiological situation scale based on the level of last week's mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

Time indicators by country

These tables summarize a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

EU+EFTA+UK countries

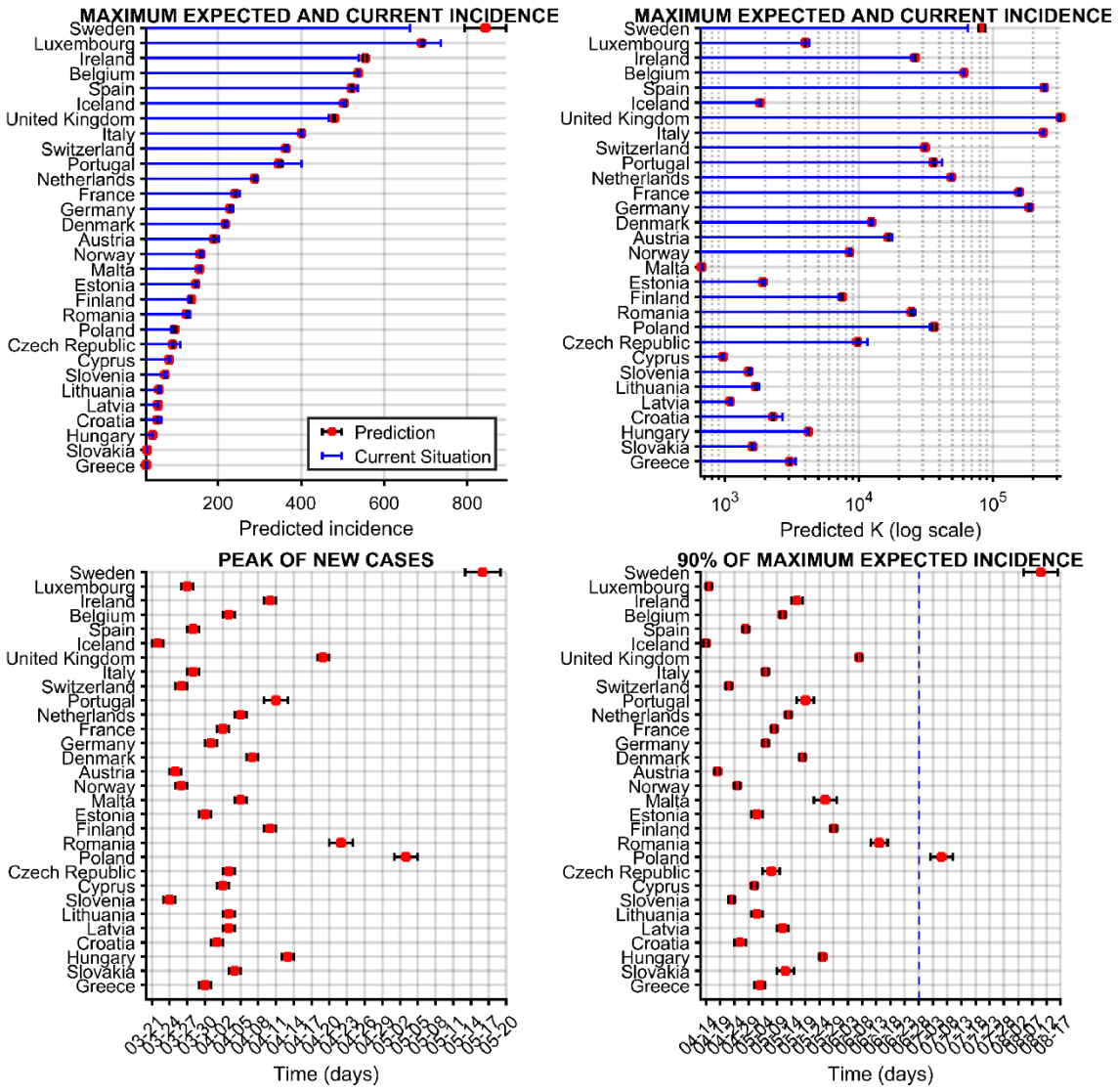
Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	127	11	16
Germany	121	12	17
France	120	10	20
Spain	120	8	12
Belgium	117	10	15
UnitedKingdom	116	10	12
Netherlands	115	11	20
Sweden	115	10	28
Norway	115	2	7
Switzerland	115	8	11
Austria	113	10	14
Denmark	112	4	30
CzechRepublic	109	11	94
Finland	109	12	46
Greece	109	18	NA
Iceland	109	5	15
Portugal	108	9	15
Slovenia	108	6	NA
Estonia	107	5	30
Ireland	107	8	18
Poland	107	17	NA
Romania	107	15	66
Luxembourg	104	6	7
Slovakia	103	24	NA
Bulgaria	102	30	NA
Croatia	102	12	NA
Hungary	101	20	NA
Latvia	101	12	NA
Lithuania	100	9	NA
Malta	99	9	35
Cyprus	98	12	NA

Other countries

Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Iran	124	11	42
United States of America	119	8	15
Canada	110	11	27
Qatar	110	3	31
Brazil	107	20	34
Saudi Arabia	106	21	29
Chile	105	13	36
Pakistan	105	35	NA
India	105	38	NA
Russia	104	15	24
Peru	104	18	22
Ecuador	104	10	30
Mexico	103	25	47
Argentina	102	39	54
Belarus	91	10	18

Long-term predictions

Evaluated with the **whole historical series**. Up-left: Predictions of maximum incidences per country **at the end of the first wave** (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country at the end of the first wave (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.



Final expected value for EU+EFTA+UK as a whole is not shown any more, since we are in the tail (see Analysis section in Report #87, https://upcommons.upc.edu/handle/2117/190497).

Situation and trends in Italian and Spanish regions

Italy

Data from **26th June**,

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 (1)	EPG_{REP} (2)	EPG_{EST} (3)	Biocom-Cov degree
Lombardia	93,587	932.0	16,624	165.5	2,383	23.7	42,873	426.1	0.67	16	284	3
Piemonte	31,311	718.7	4,077	93.6	322	7.4	4,185	96.1	0.76	6	73	2
Emilia Romagna	28,393	636.7	4,252	95.3	365	8.2	5,531	124.0	1.50	12	186	3
Veneto	19,262	392.6	2,007	40.9	63	1.3	619	12.6	1.03	1	13	1
Toscana	10,226	274.2	1,103	29.6	61	1.6	663	17.8	0.81	1	14	1
Liguria	9,958	642.2	1,556	100.3	87	5.6	1,384	89.2	1.13	6	101	2
Lazio	8,064	137.2	836	14.2	148	2.5	1,563	26.6	0.97	2	26	2
Marche	6,783	444.7	991	65.0	31	2.0	446	29.2	1.65	3	48	2
Trento	4,859	453.1	405	37.8	416	38.8	3,743	695.8	3.37	131	2,344	8
Campania	4,665	80.4	431	7.4	57	1.0	NA	NA	3.20	3	NA	2
Puglia	4,531	112.5	543	13.5	16	0.4	200	5.0	2.49	1	12	1
Friuli Venezia Giulia	3,307	272.1	345	28.4	17	1.4	170	14.0	0.89	1	12	1
Abruzzo	3,285	250.5	461	35.1	14	1.1	193	14.7	1.21	1	18	1
Sicilia	3,076	61.5	281	5.6	NA	NA	NA	NA	NA	NA	NA	NA
Bolzano	2,634	2,451.7	292	271.8	26	24.2	288	55.3	0.94	23	52	2
Umbria	1,440	163.3	79	9.0	4	0.5	NA	NA	0.86	0	NA	1
Sardegna	1,362	83.1	132	8.1	NA	NA	NA	NA	NA	NA	NA	NA
Valle dAosta	1,194	950.6	146	116.2	3	2.4	37	29.1	1.14	3	33	2
Calabria	1,178	60.5	97	5.0	17	0.9	NA	NA	2.70	2	NA	1
Molise	445	145.6	23	7.5	6	2.0	NA	NA	1.50	3	NA	2
Basilicata	401	71.2	27	4.8	0	0.0	NA	NA	0.00	0	NA	0

Scale											
Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100	1000
Best	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0	0

Spain

Data from **23rd June**, series built with the day of symptoms' onset

	Reported data				Indexes		
Autonomous regions	Cumulative cases	Attack rate /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	ρ_7 (1)	EPG_{REP} (2)	Biocom-Cov degree
Madrid	71,679	1,079.4	743	11.2	0.87	10	3
Catalunya	56,159	742.3	1,046	13.8	1.43	20	3
Castilla y Leon	26,597	1,104.5	238	9.9	1.01	10	3
Castilla-La Mancha	22,253	1,093.2	185	9.1	0.89	8	2
Andalucia	16,699	198.2	220	2.6	2.58	7	2
Comunitat Valenciana	14,805	297.6	76	1.5	0.67	1	1
Euskadi	14,569	668.9	110	5.1	0.98	5	2
Galicia	10,739	397.7	45	1.7	2.13	4	2
Navarra	7,884	1,213.0	96	14.8	2.03	30	3
Aragon	6,850	518.6	412	31.2	3.0	94	5
Extremadura	5,660	531.3	38	3.6	1.60	6	2
La Rioja	3,993	1,273.4	6	1.9	1.07	2	1
Canarias	2,497	113.1	44	2.0	0.33	1	1
Murcia	2,462	165.5	35	2.4	1.28	3	2
Asturias	2,435	238.2	0	0.0	0.00	0	0
Cantabria	2,349	403.8	25	4.3	1.62	7	2
Baleares	2,329	196.1	48	4.0	0.81	3	2
Ceuta	222	261.7	0	0	NA	NA	0
Melilla	139	164.1	3	3.5	NA	NA	0

Scale					
Worst	Worst	Worst	Worst	2.0	200
Best	Best	Best	Best	0.0	0

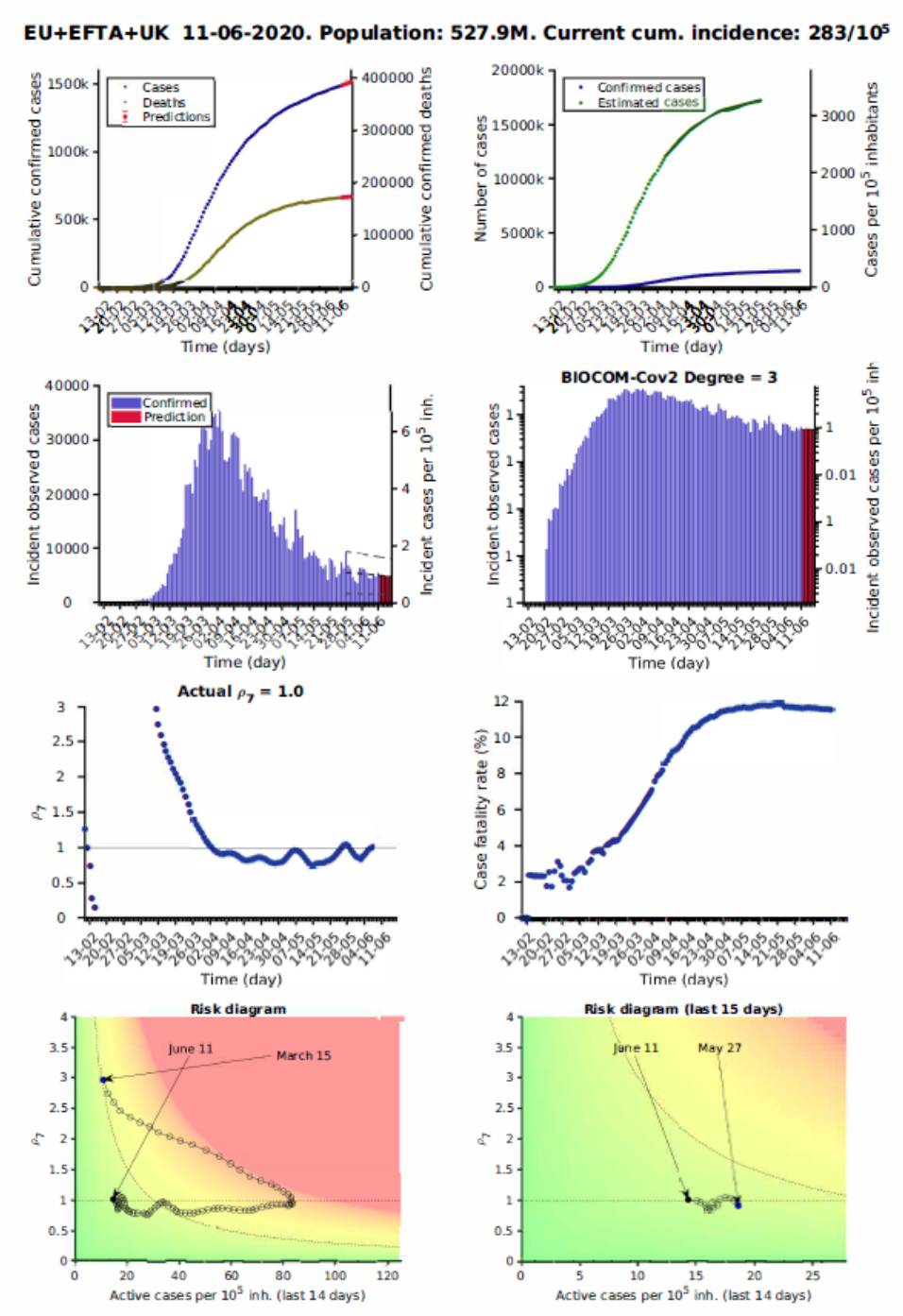
Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

(1) ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. (2,3) EPG stands for Effective Growth Potential. EPG_{REP} is the product of attack-rate of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). EPG_{EST} is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and ρ_7. Biocom-Cov degree is an epidemiological situation scale based on the level of last week's mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

Long-term predictions are not shown any more, since all Italian and Spanish regions are already in the tail (see Analysis section in Report #87, https://upcommons.upc.edu/handle/2117/190497).

Legend: Countries' reports details

Reported cumulative cases (blue) and deaths (brown), together with predictions (red



Estimated and reported cases.

Incident observed cases and predictions.

Incident observed cases in a logarithmic scale, with Biocom-Cov degree.

Evolution of empiric reproductive number ρ_7

Case fatality rate

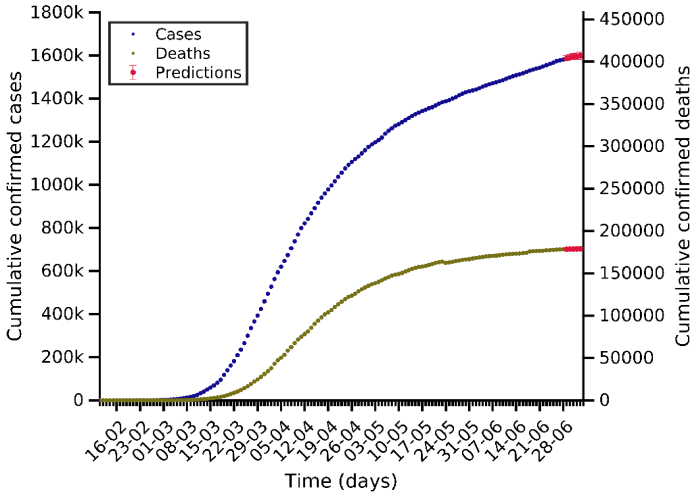
Risk diagram

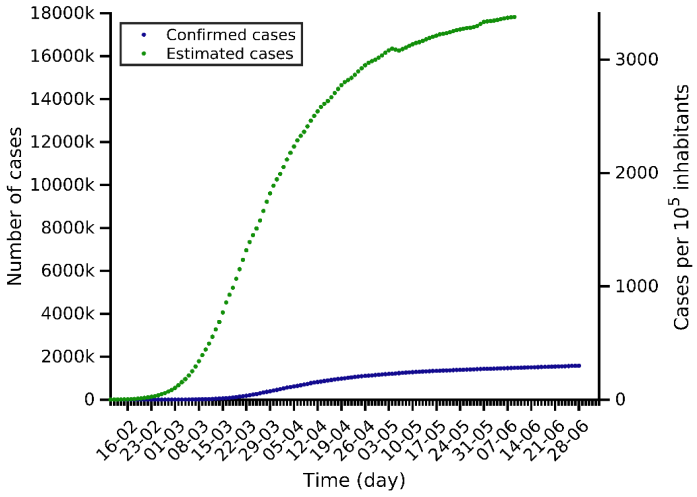
Risk diagram of last 15 days

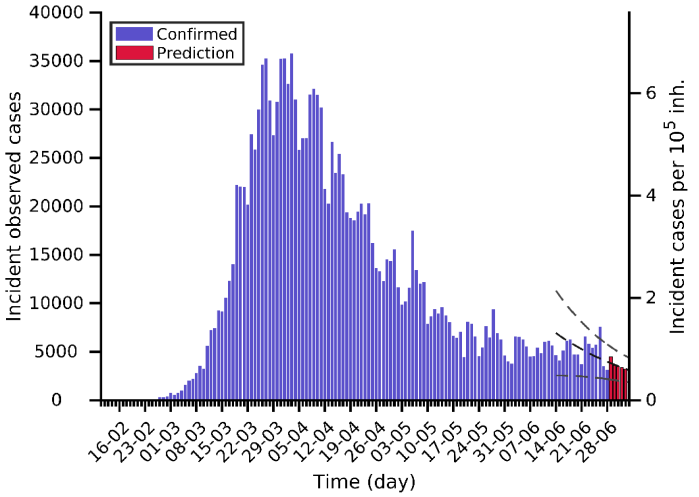
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

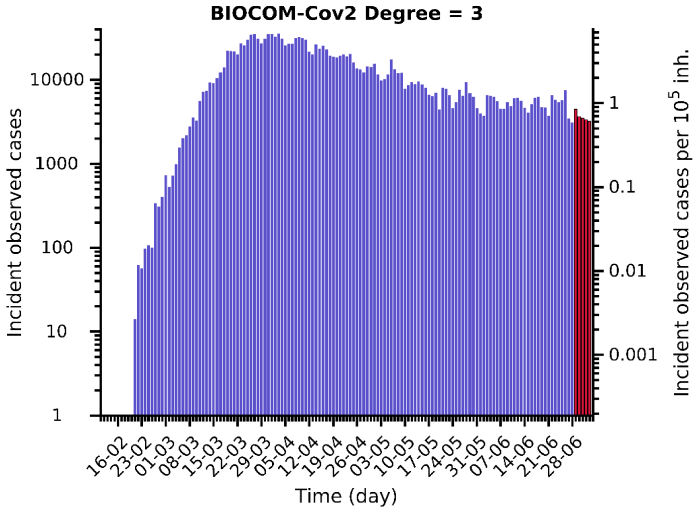
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

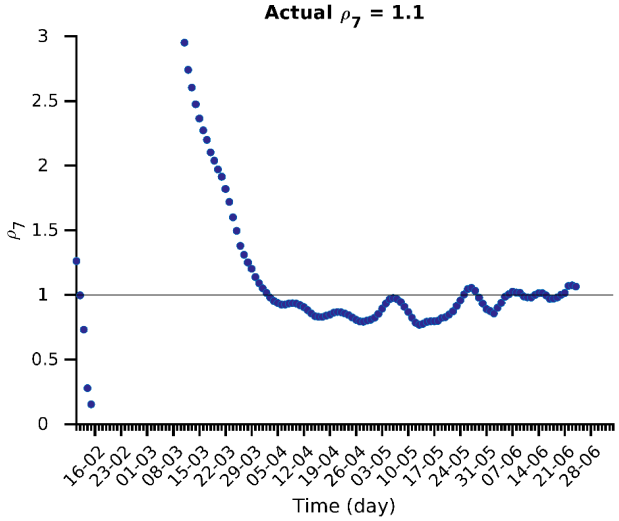
EU+EFTA+UK 28-06-2020. Population: 527.9M. Current cumulative incidence: 300/1

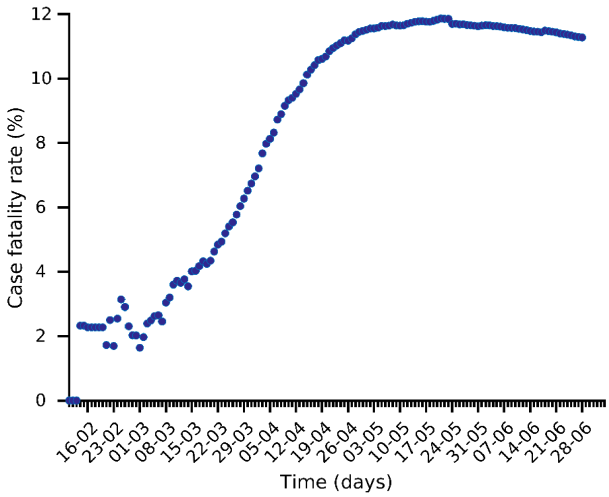


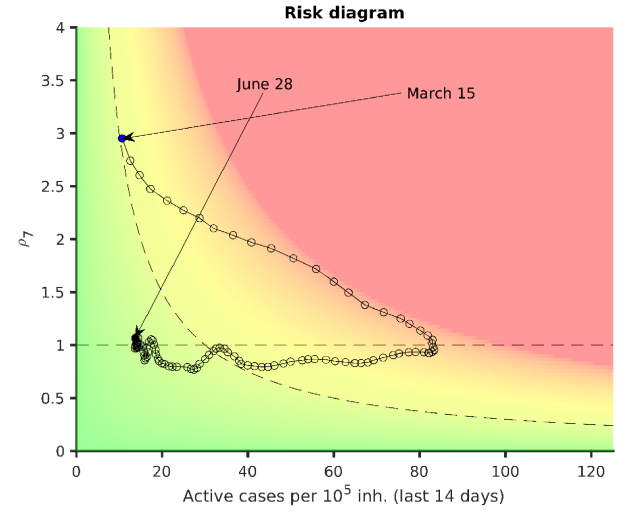


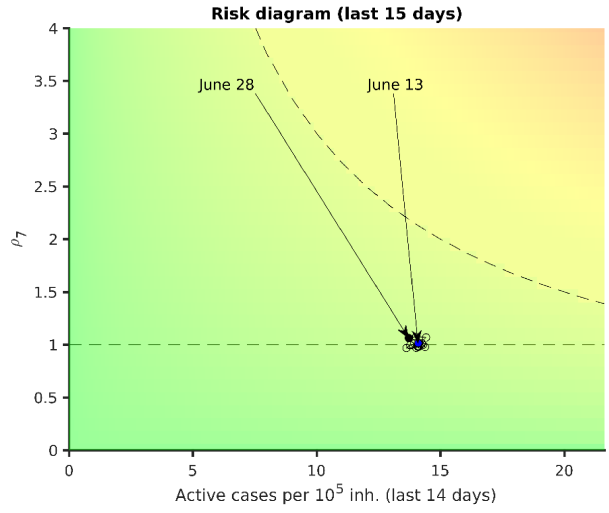




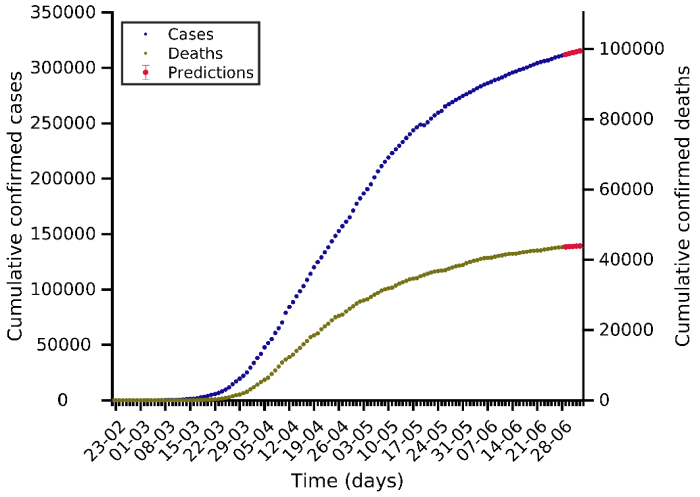


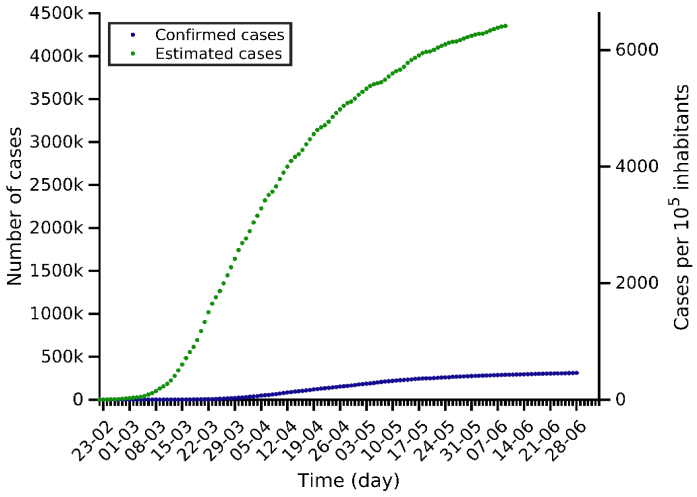


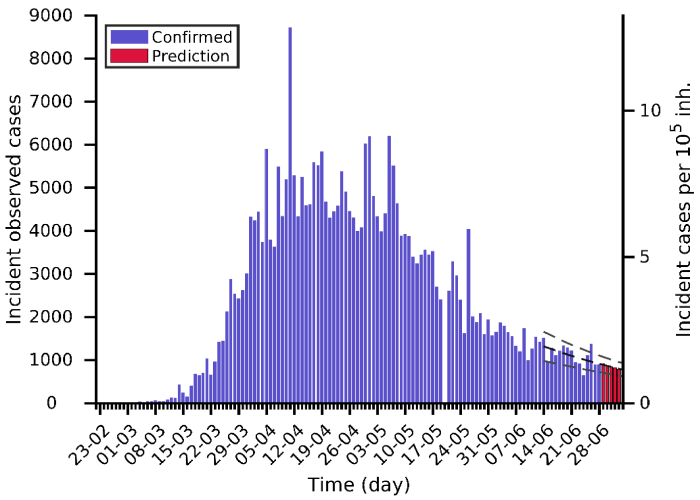


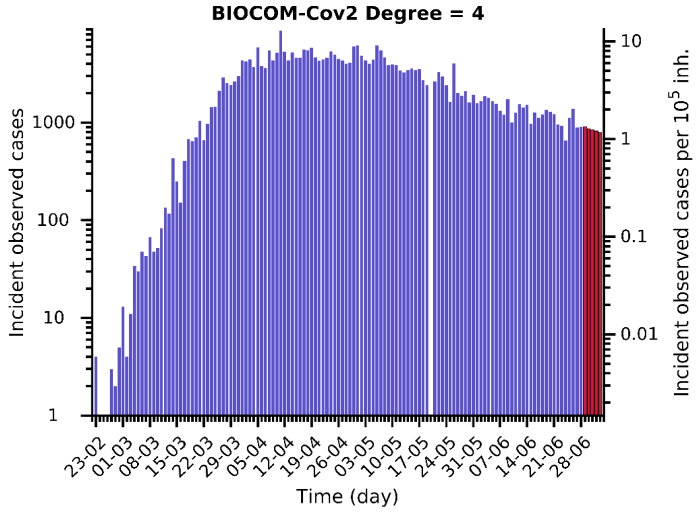


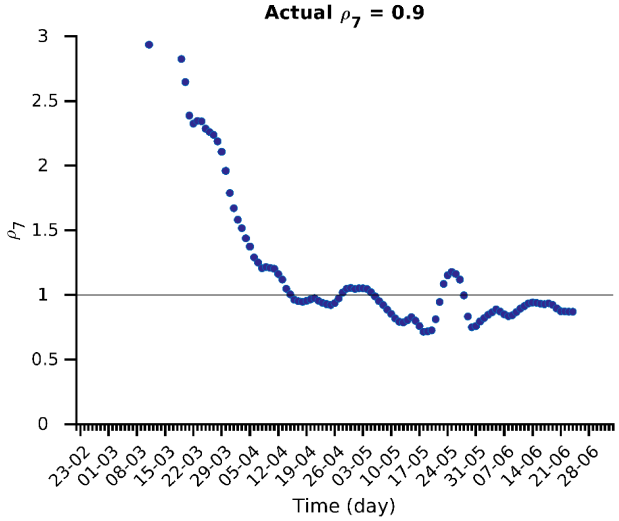
UK 28-06-2020. Population: 67.9M. Current cumulative incidence: 458/10⁵

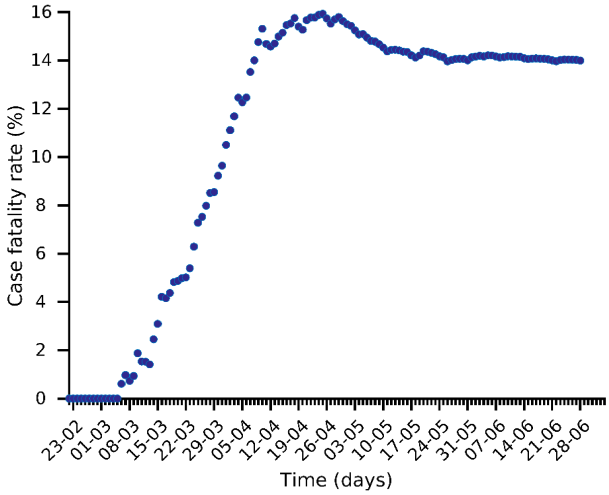


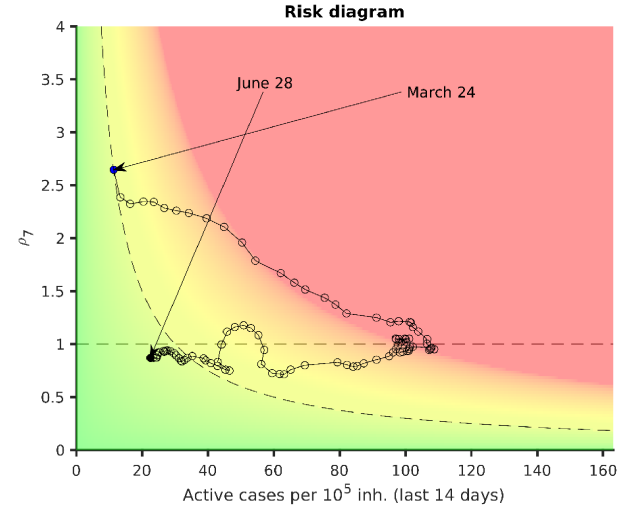


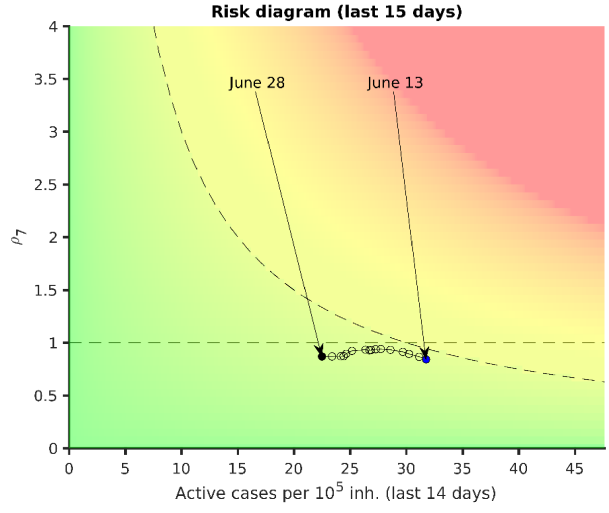




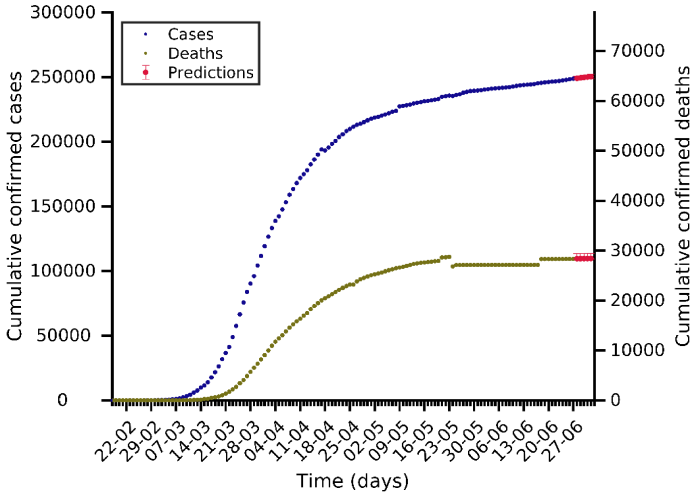


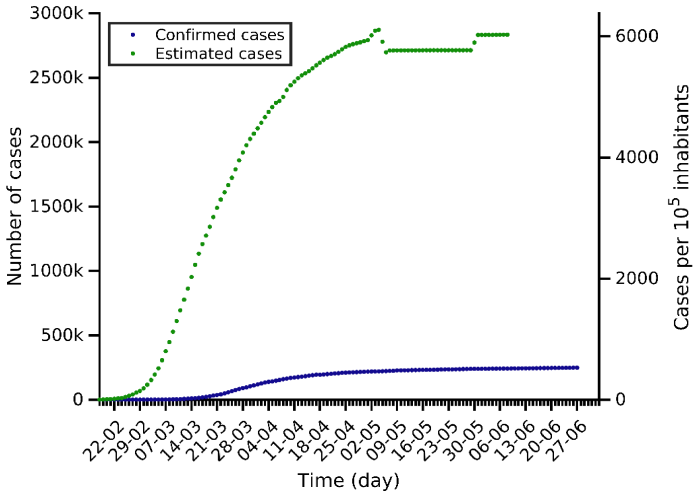


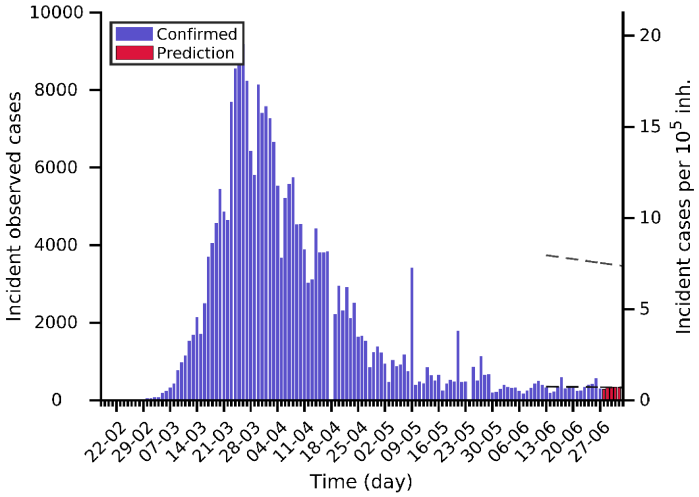


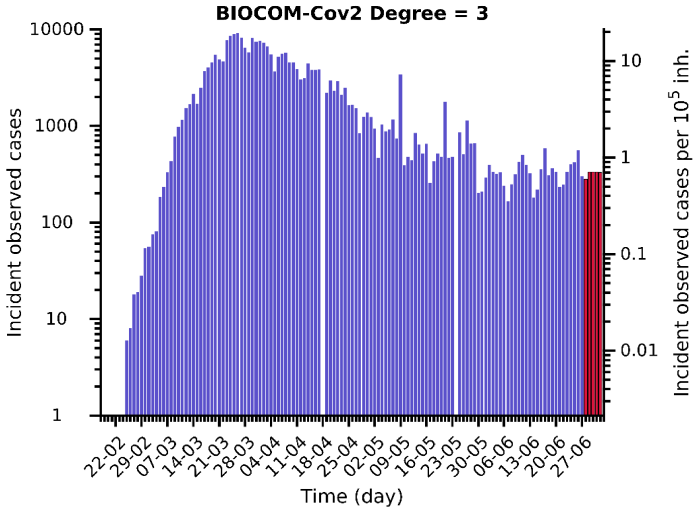


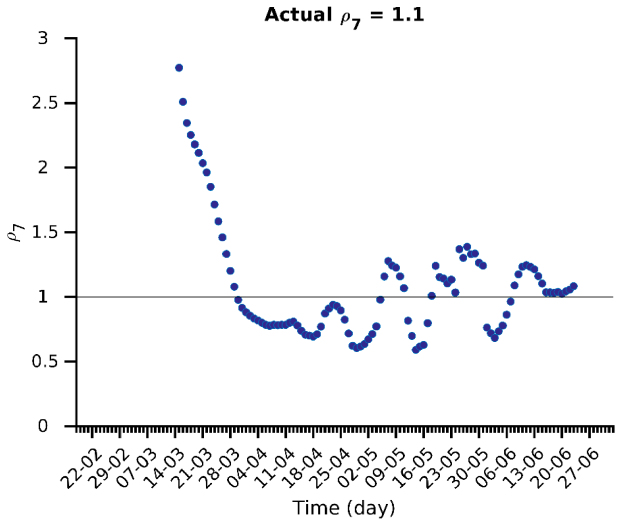
Spain 27-06-2020. Population: 47.0M. Current cumulative incidence: 529/10^5

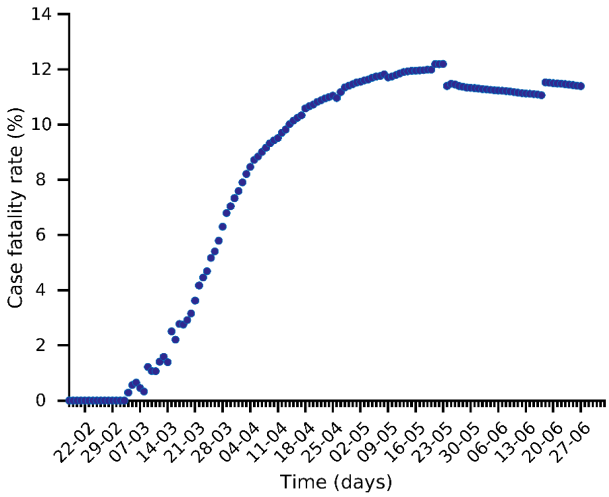


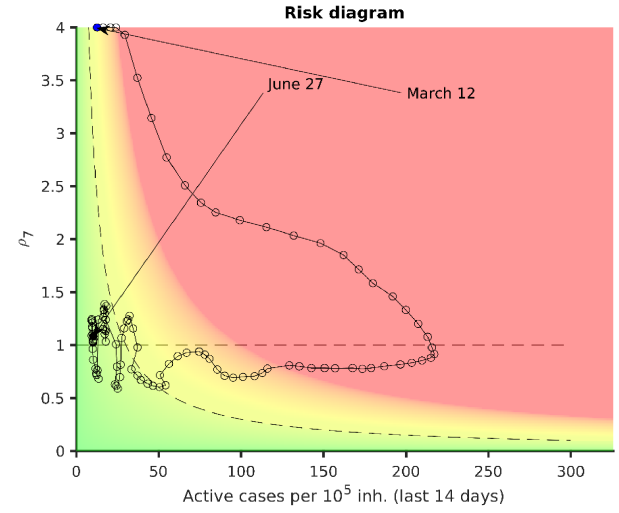


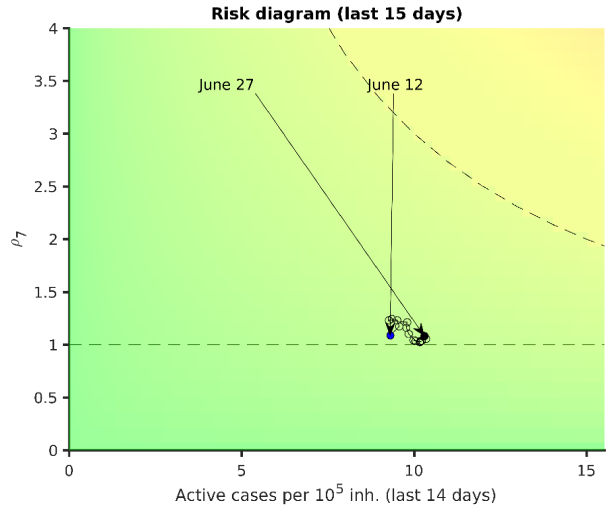




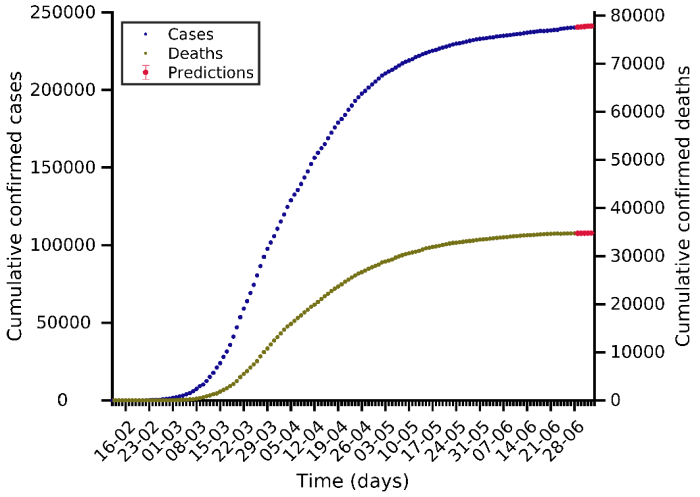


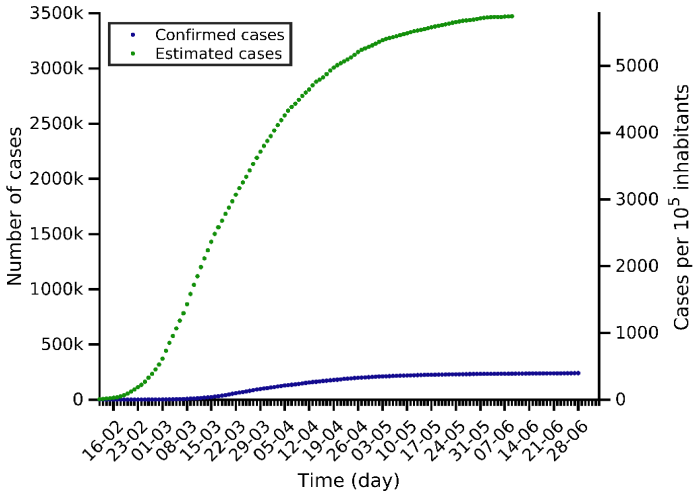


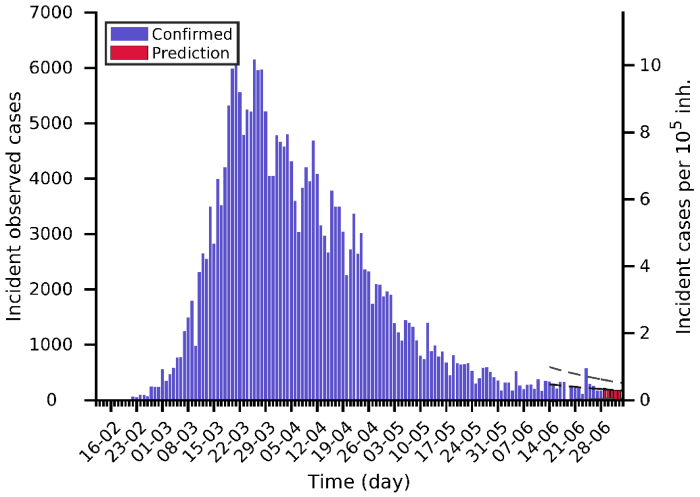


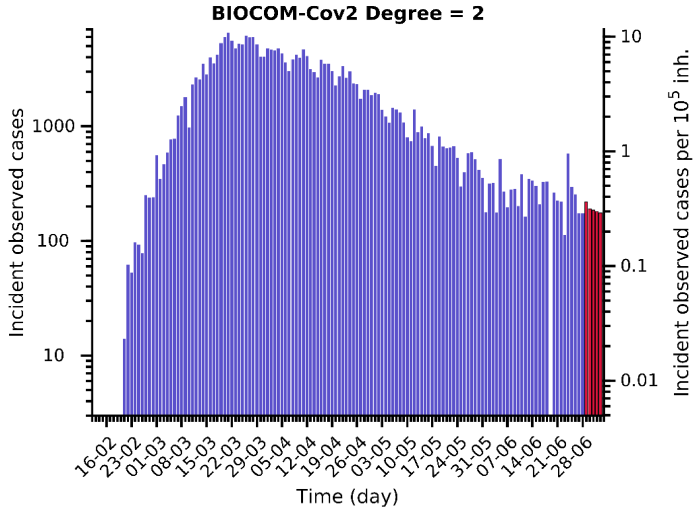


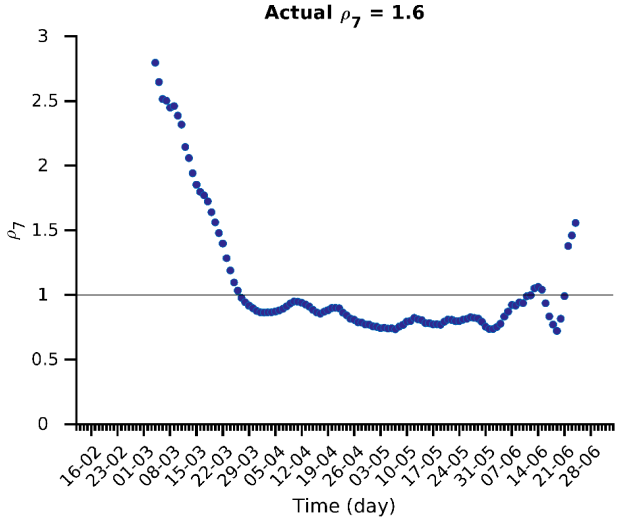
Italy 28-06-2020. Population: 60.5M. Current cumulative incidence: 397/10⁵

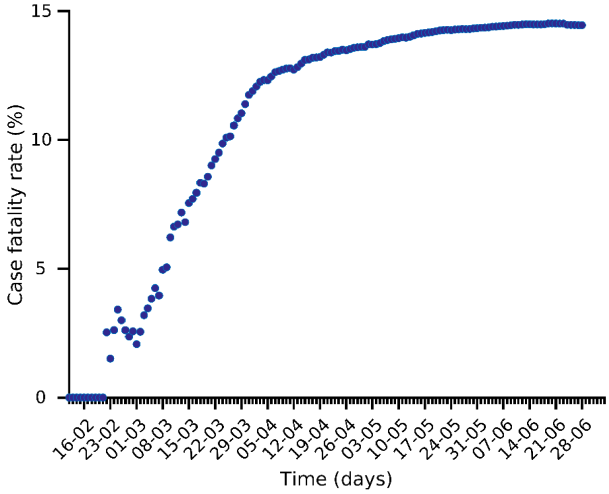


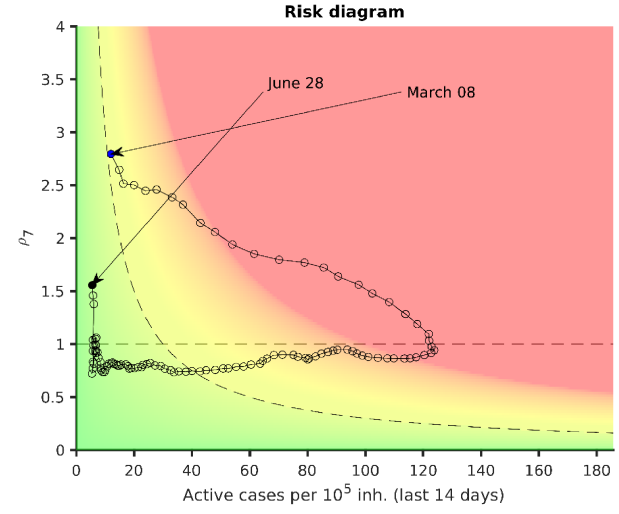


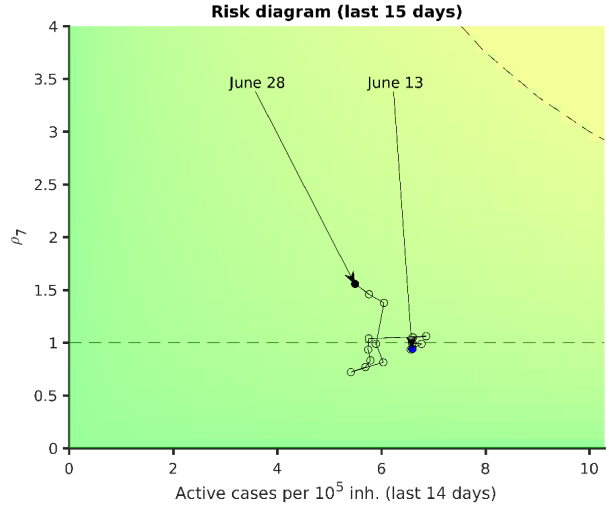




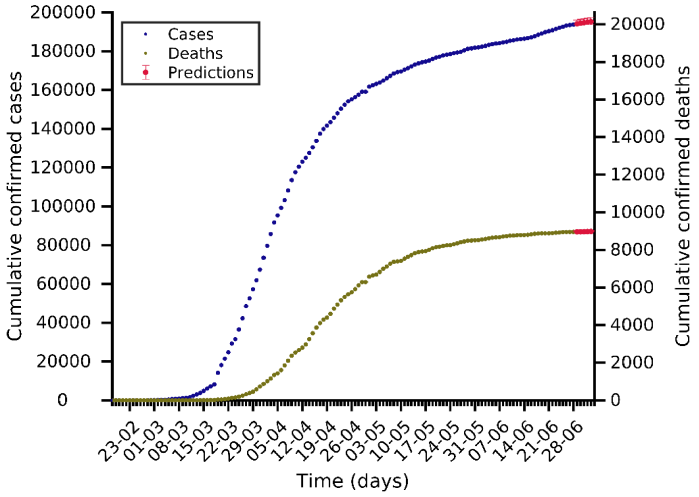


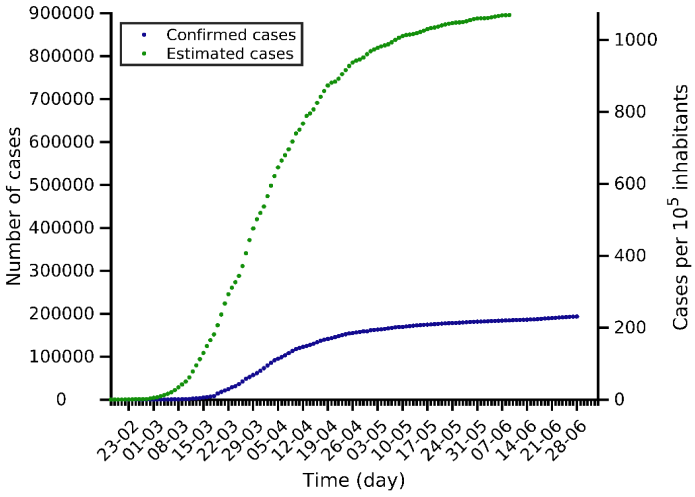


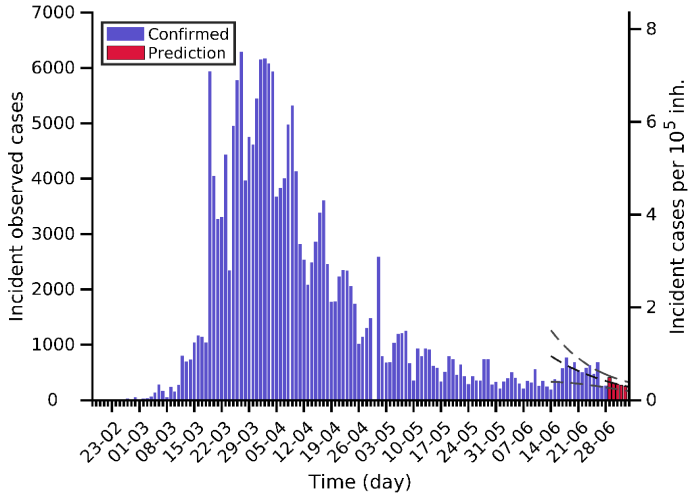


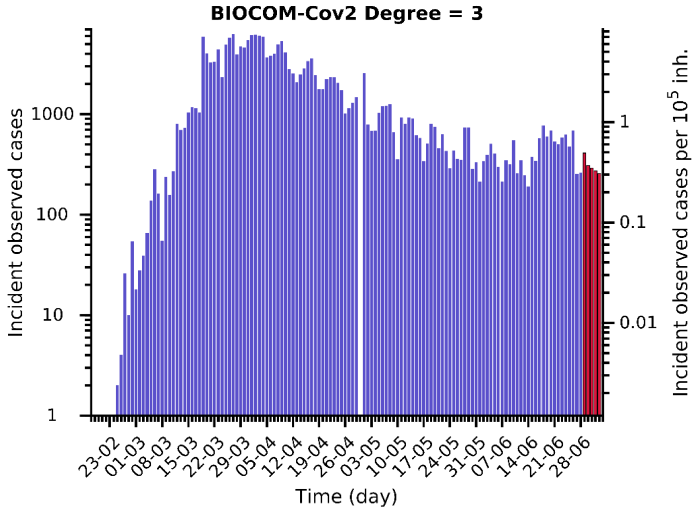


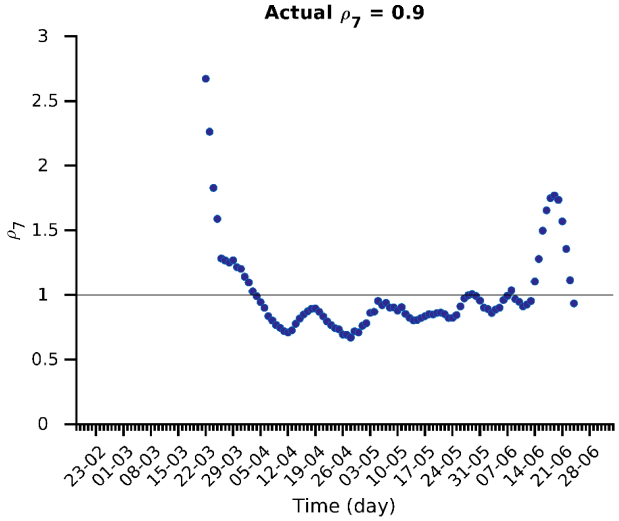
Germany 28-06-2020. Population: 83.8M. Current cumulative incidence: 231/10⁵

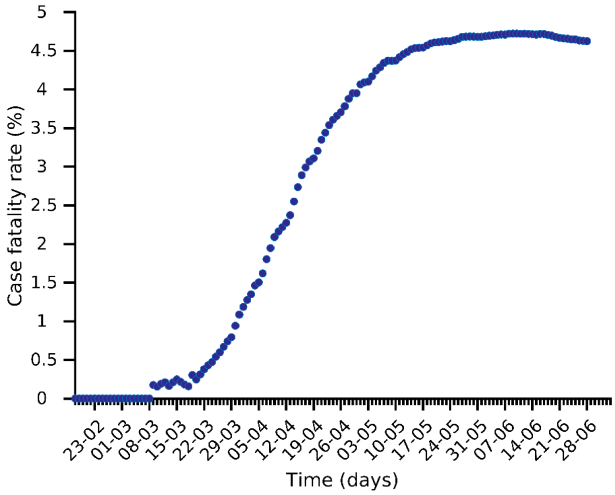


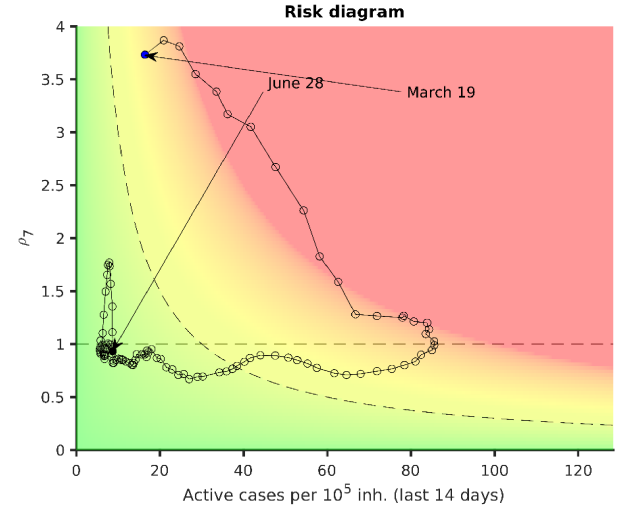


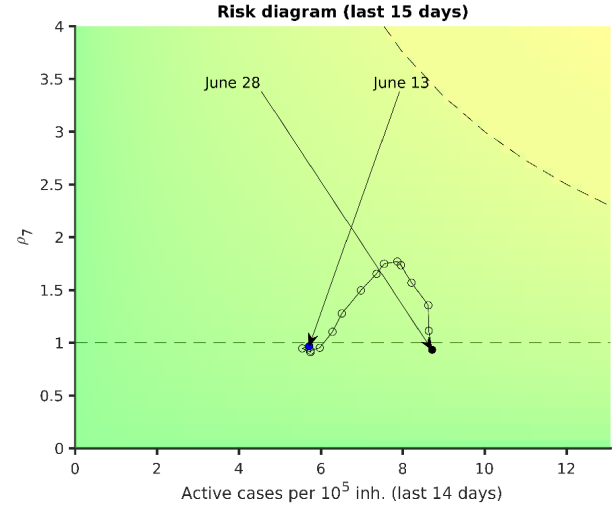




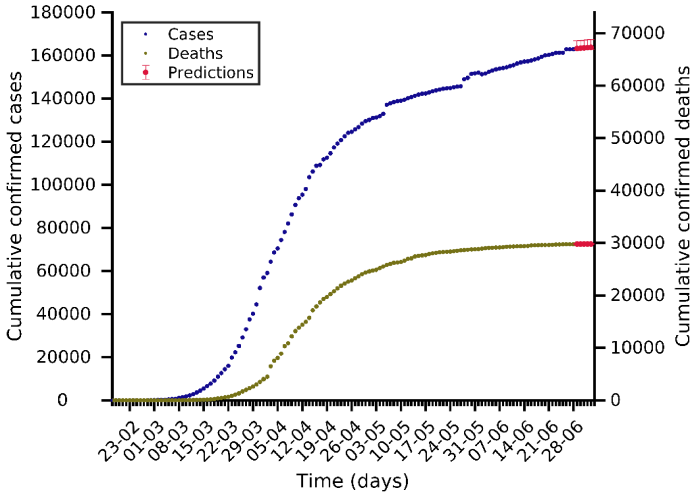


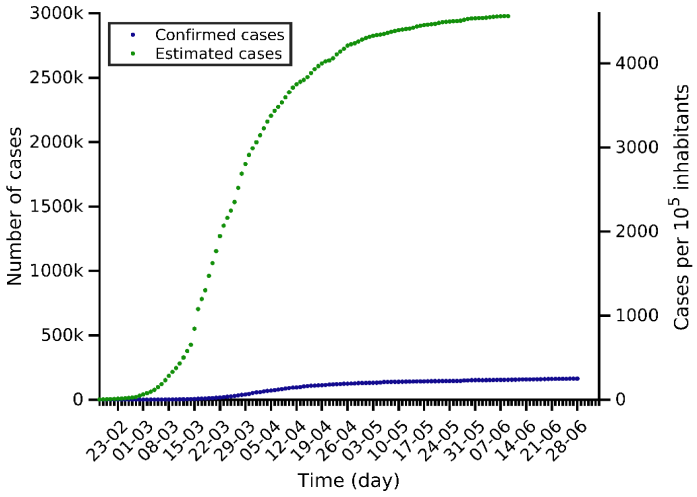


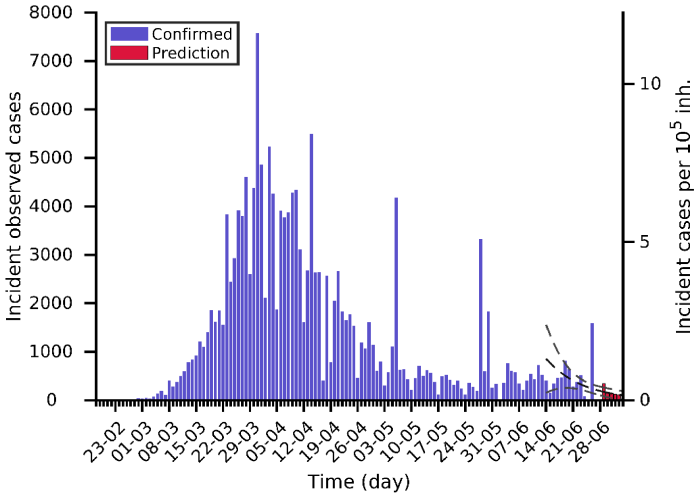


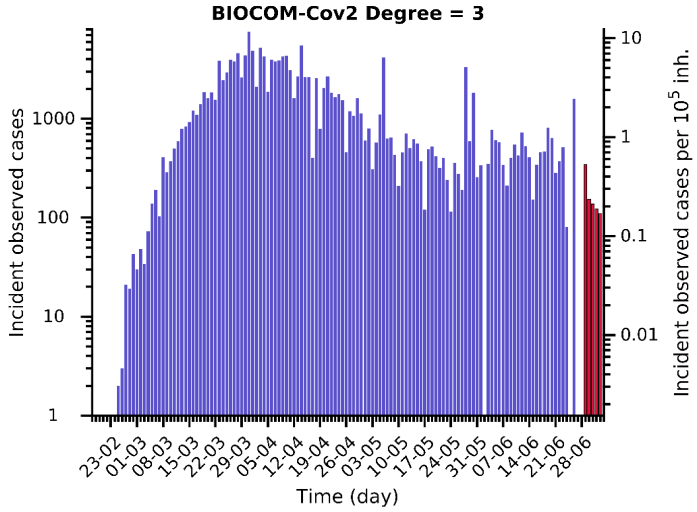


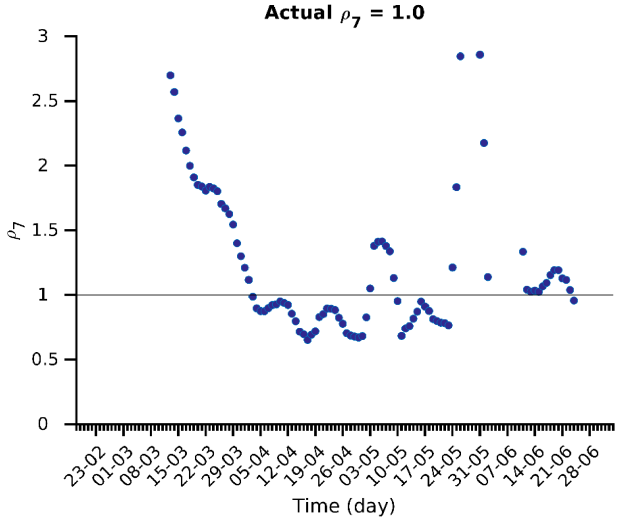
France 28-06-2020. Population: 65.3M. Current cumulative incidence: 250/10⁵

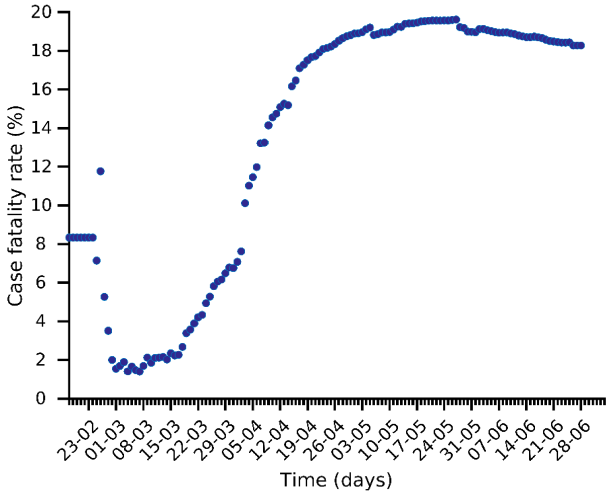


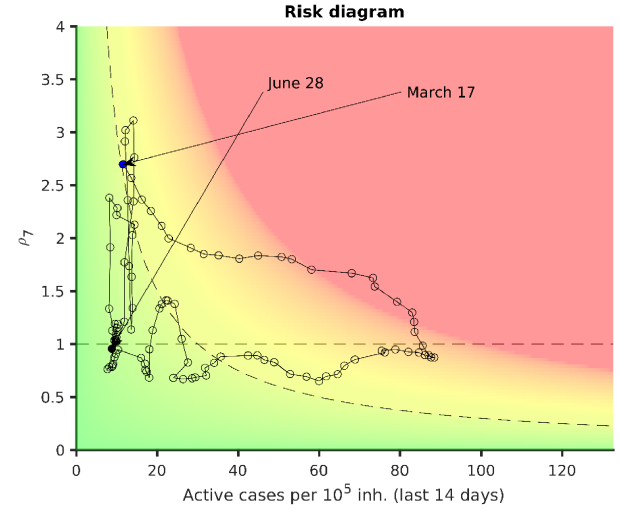


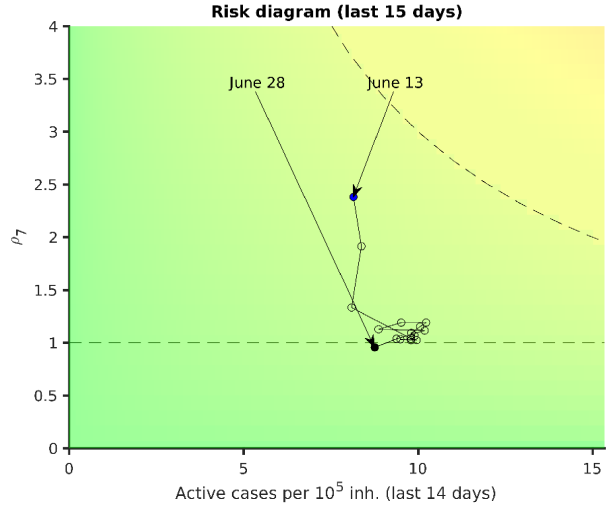




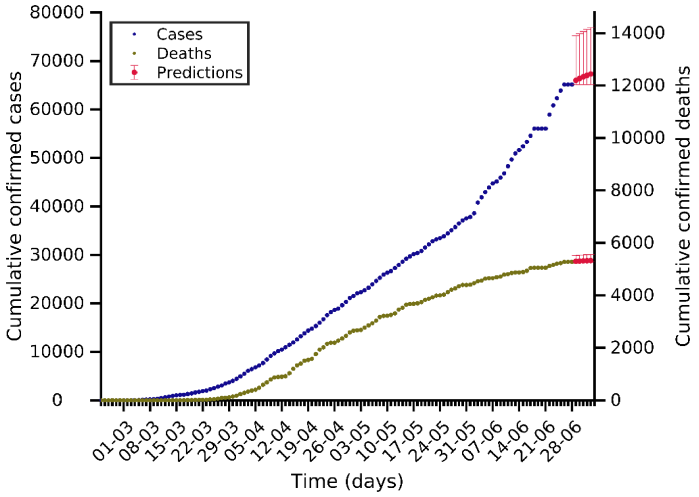


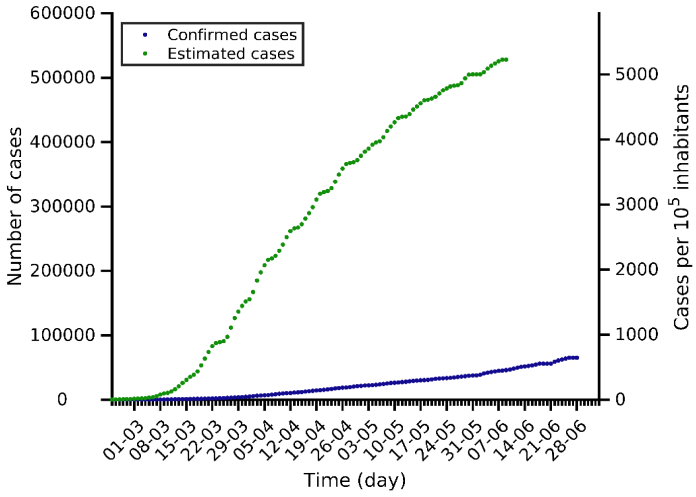


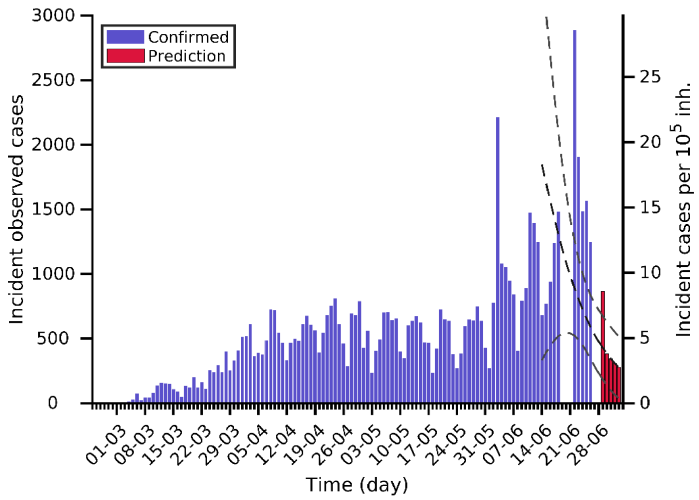


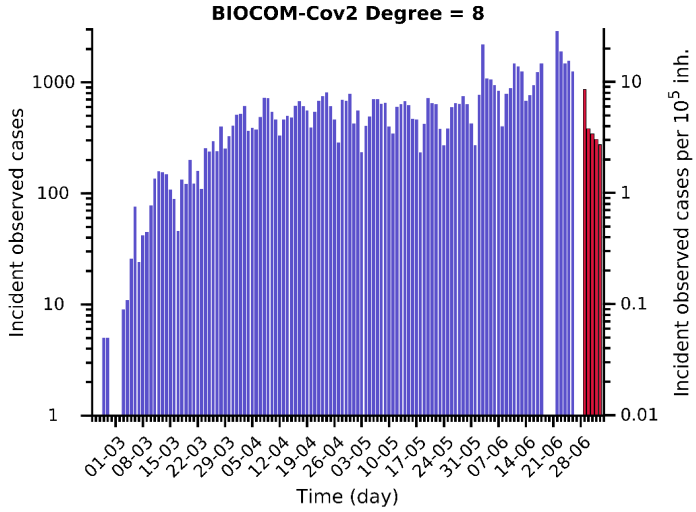


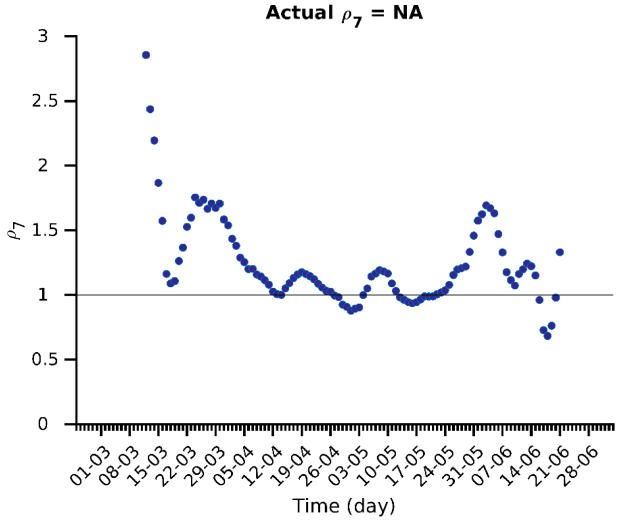
Sweden 28-06-2020. Population: 10.1M. Current cumulative incidence: 645/10⁵

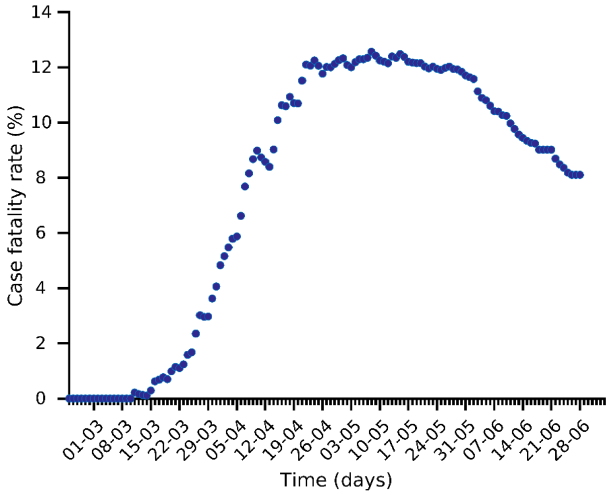


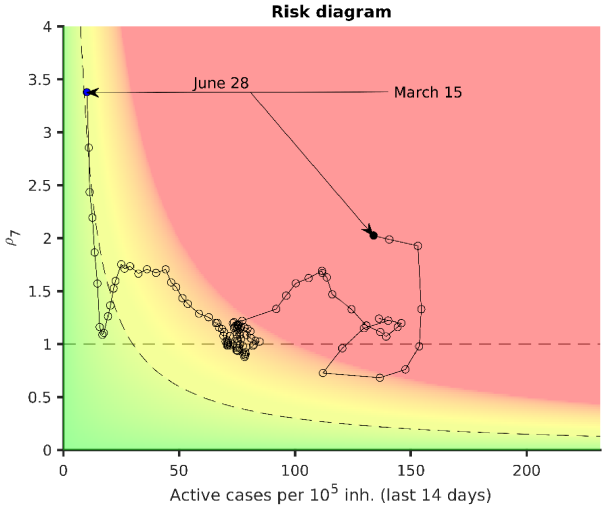


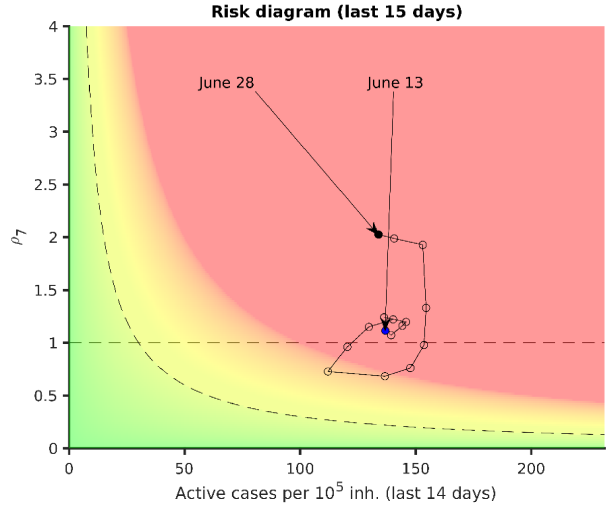




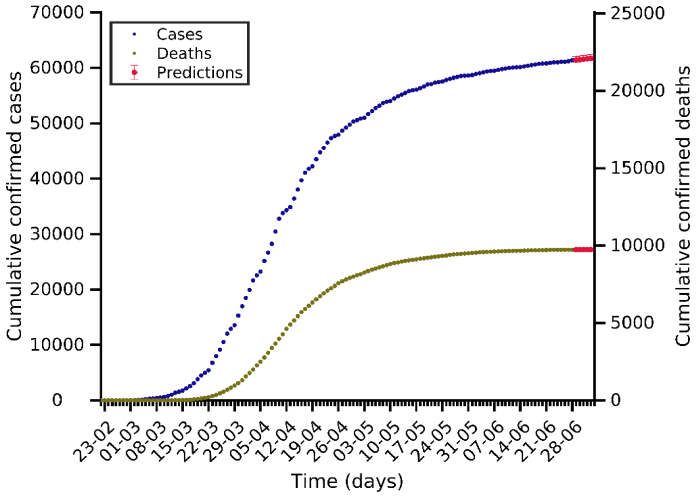


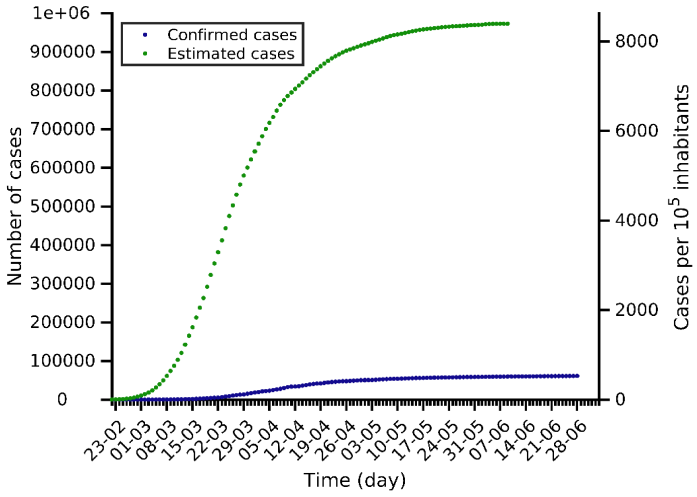


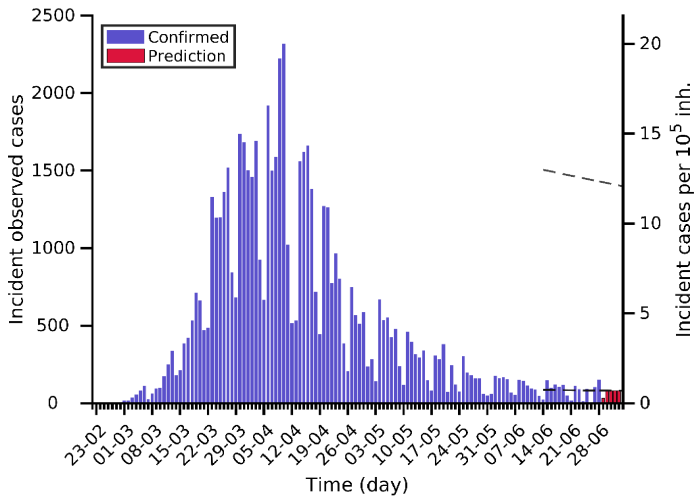


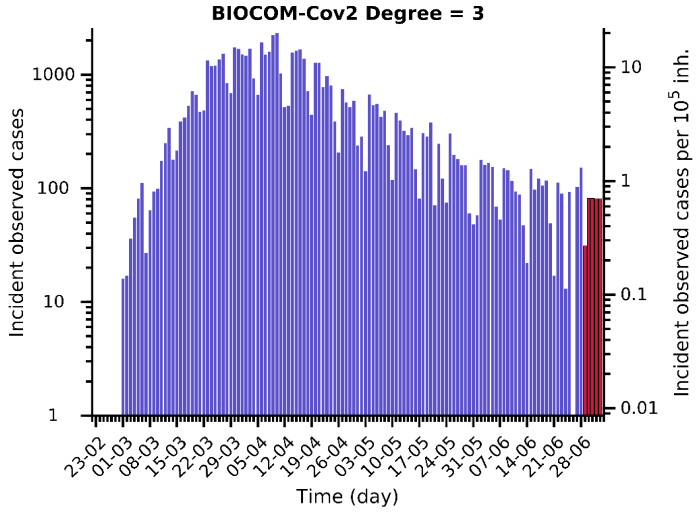


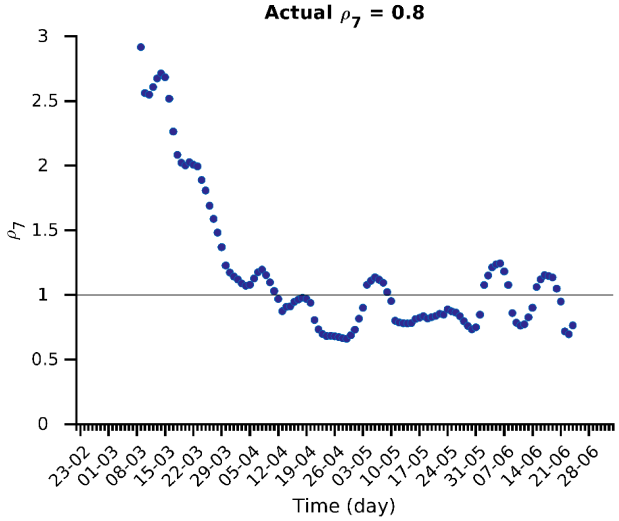
Belgium 28-06-2020. Population: 11.6M. Current cumulative incidence: 529/10⁵

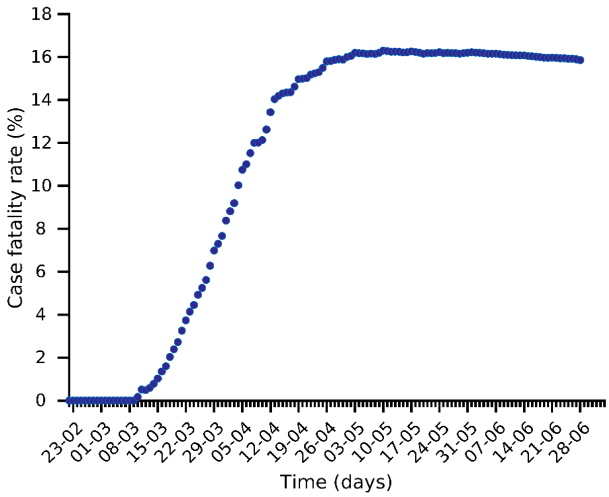


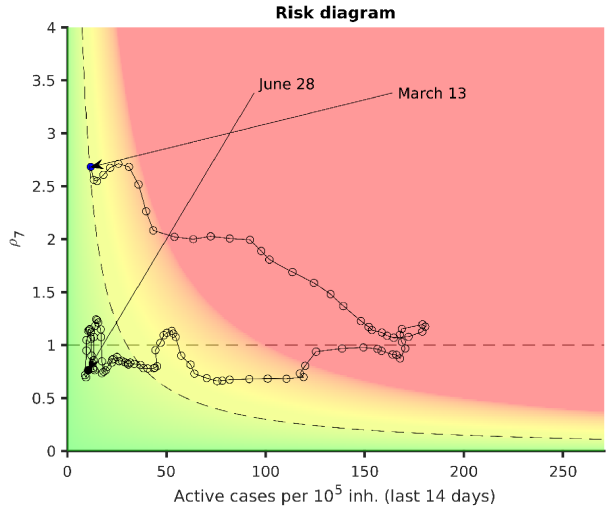


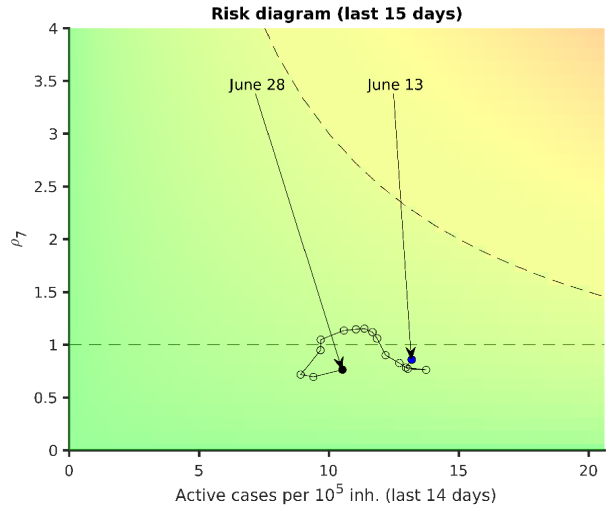




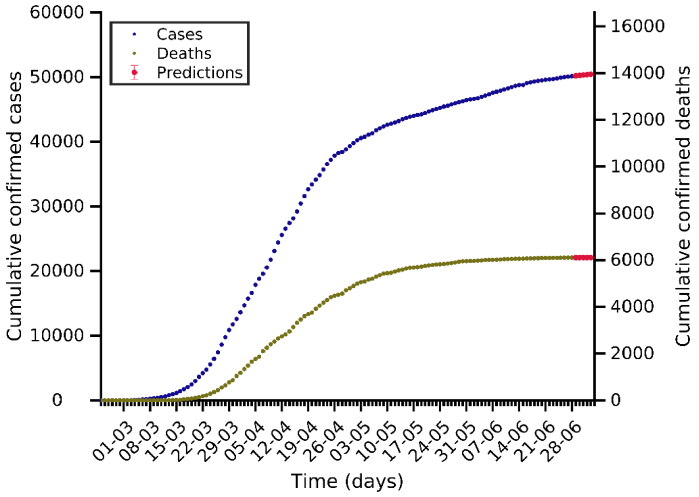


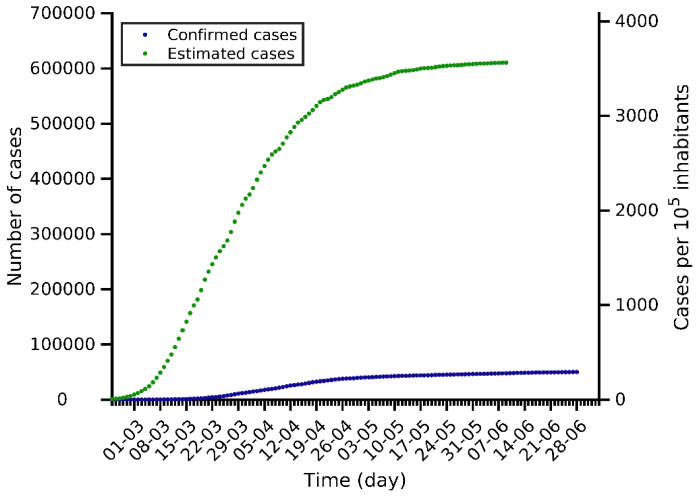


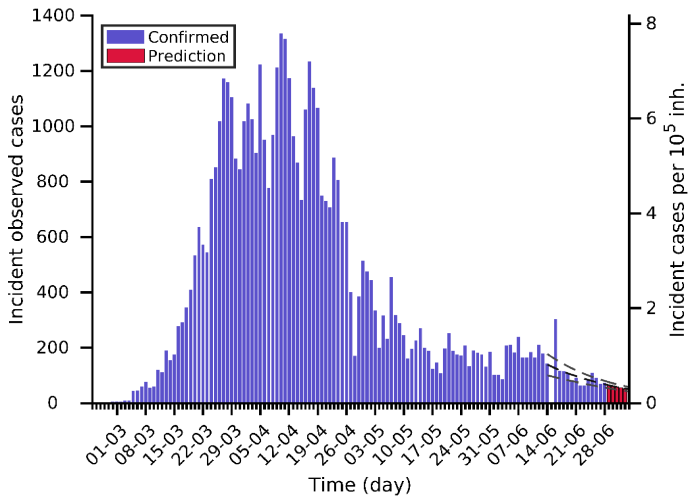


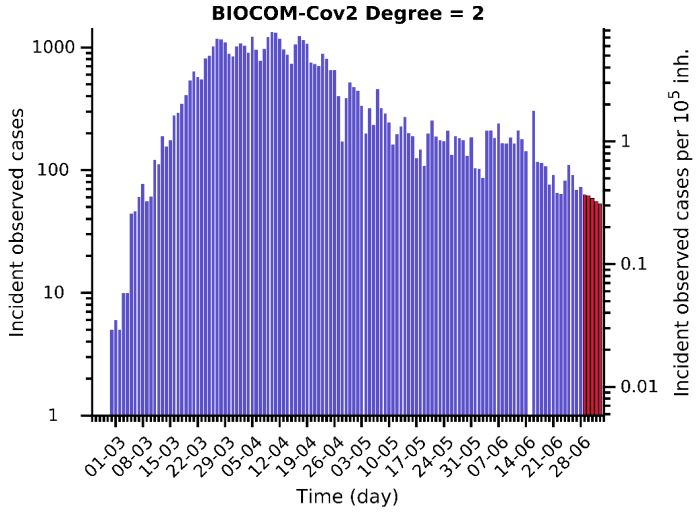


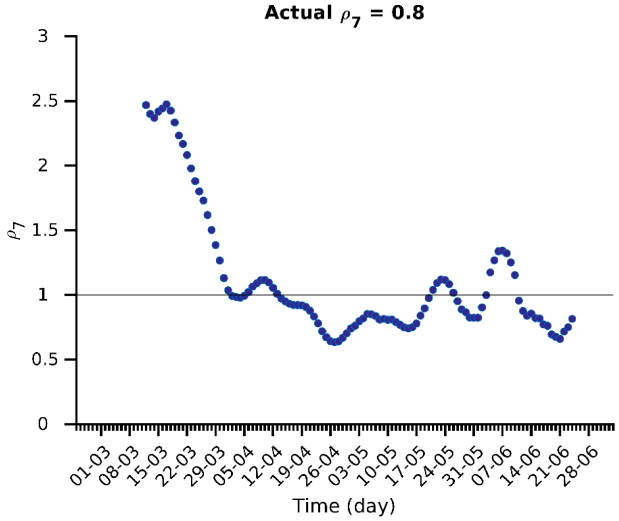
Netherlands 28-06-2020. Population: 17.1M. Current cumulative incidence: 293/10^5

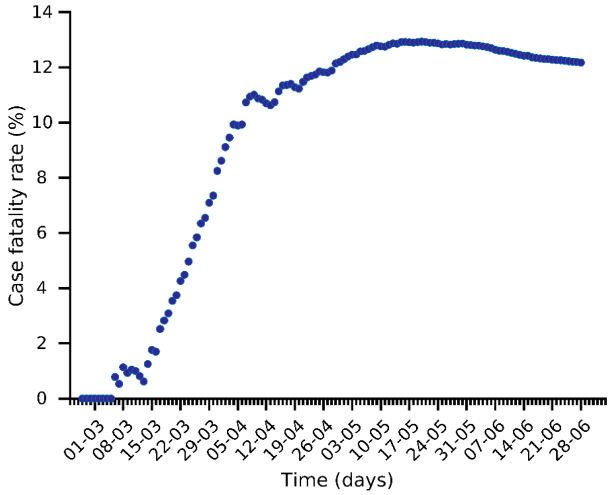


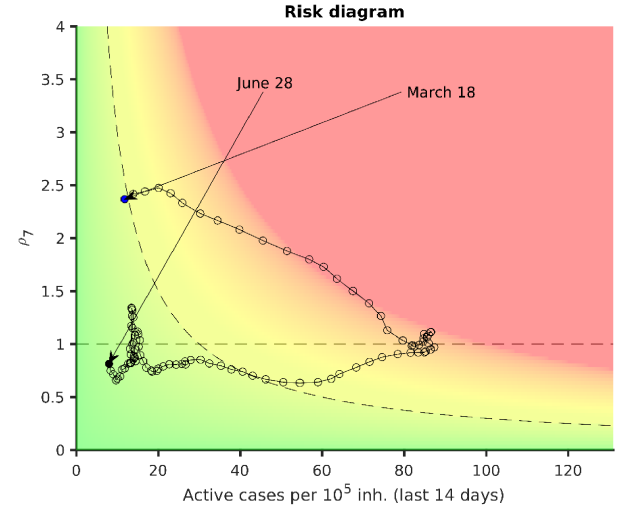


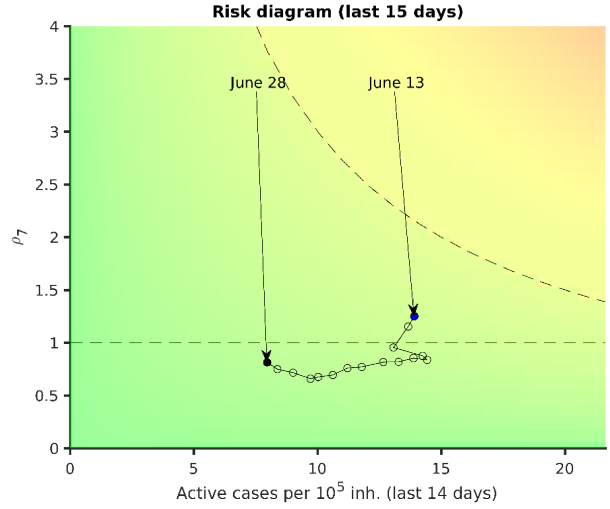




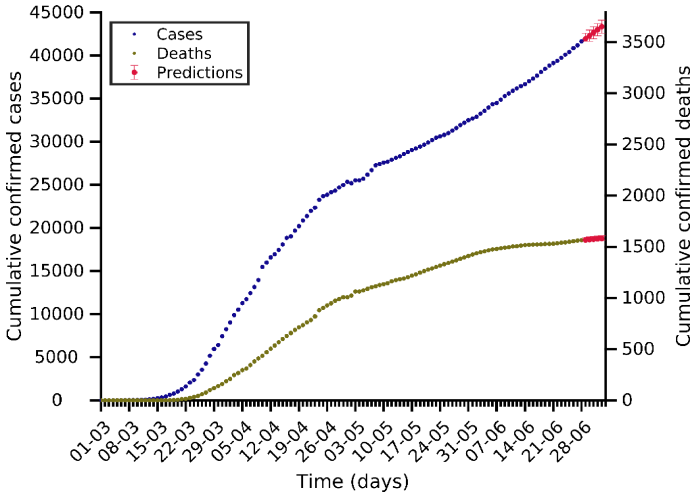


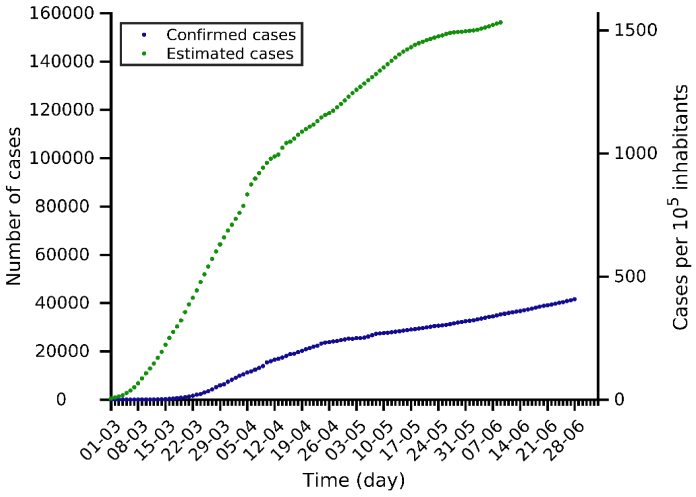


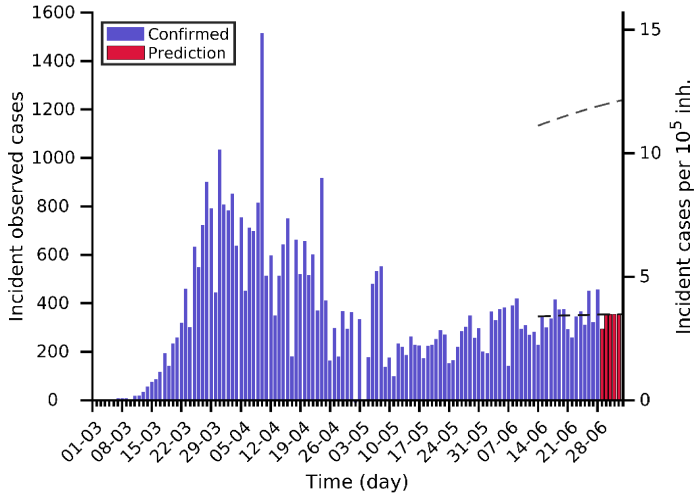


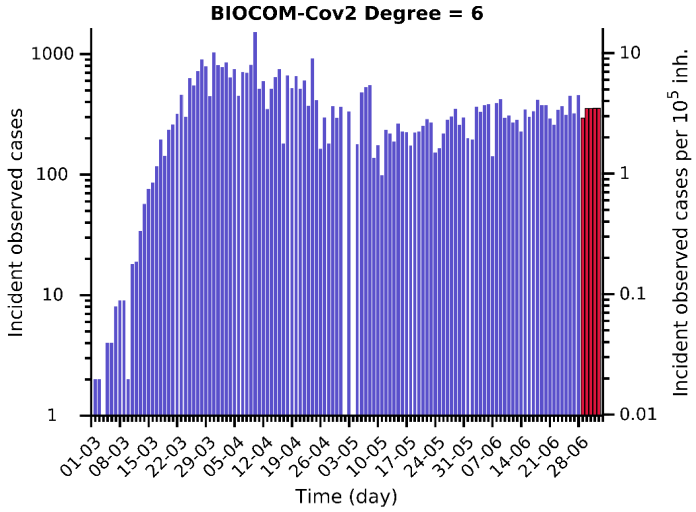


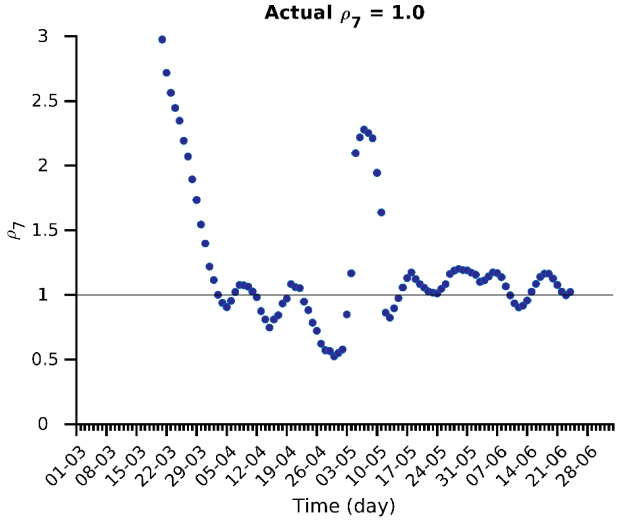
Portugal 28-06-2020. Population: 10.2M. Current cumulative incidence: 408/10^5

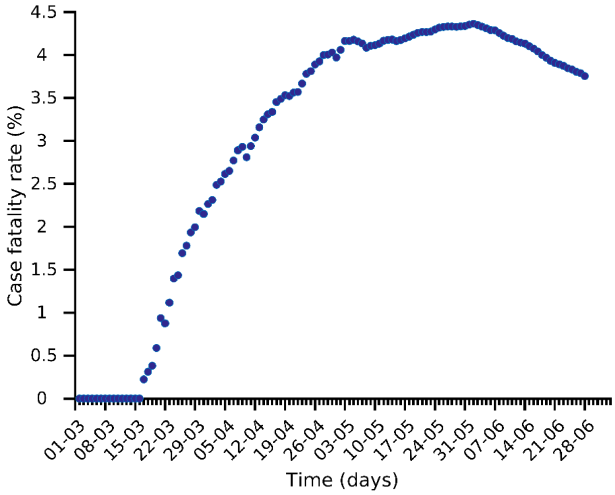


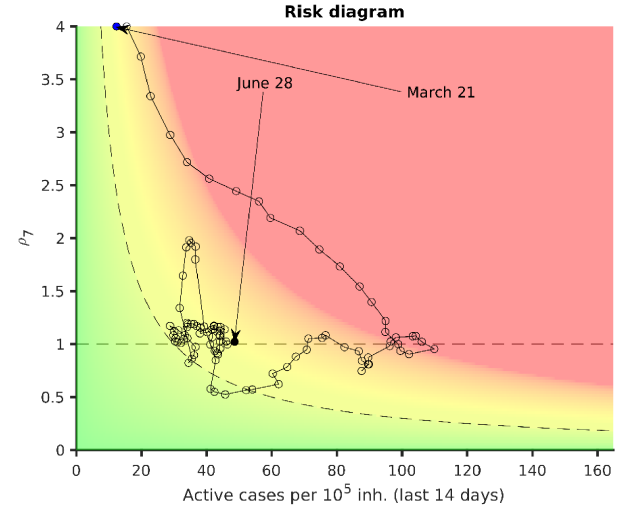


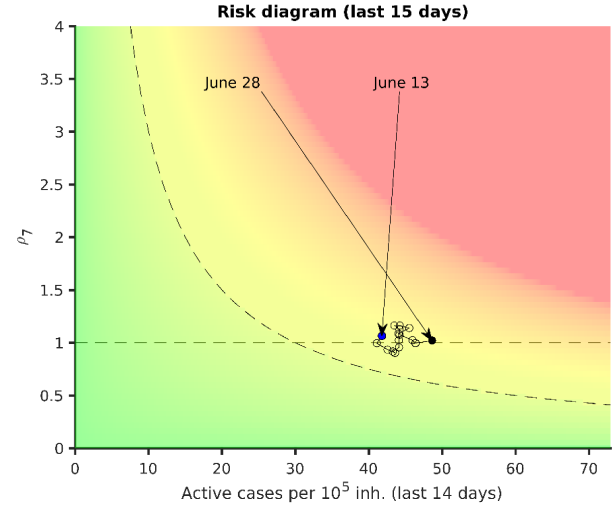




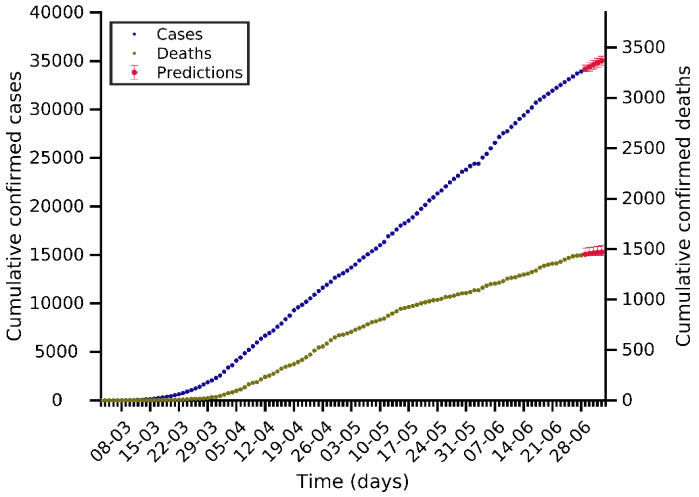


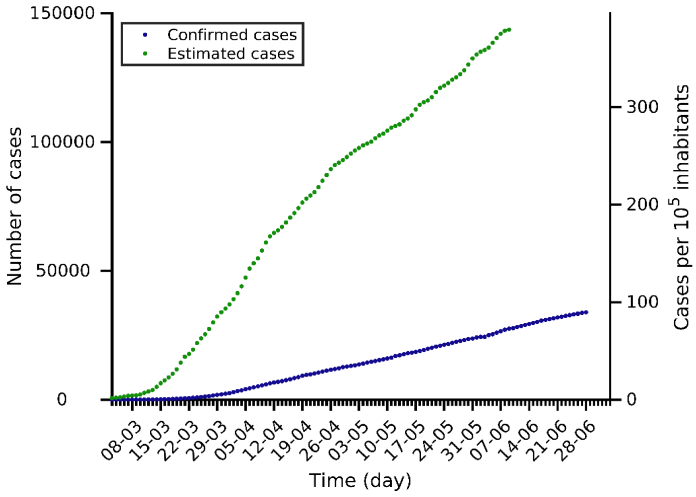


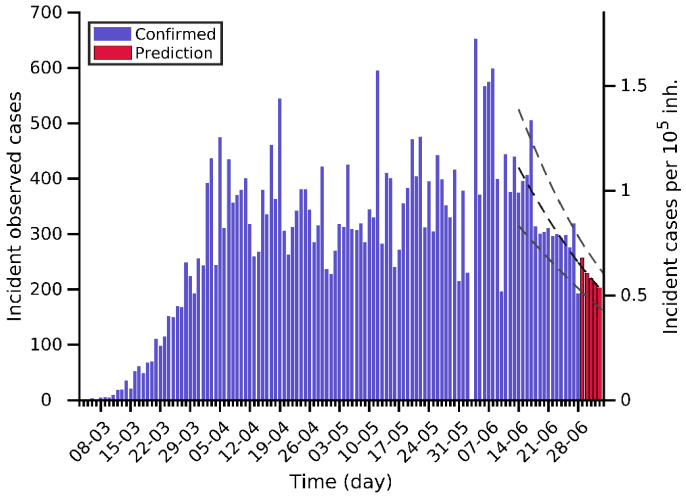


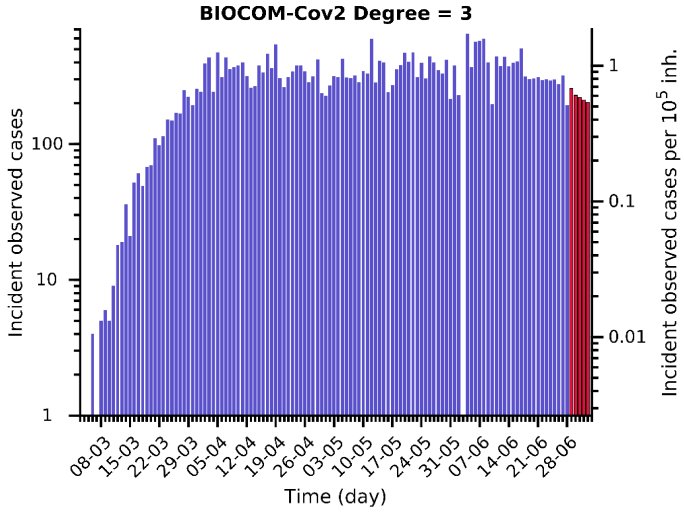


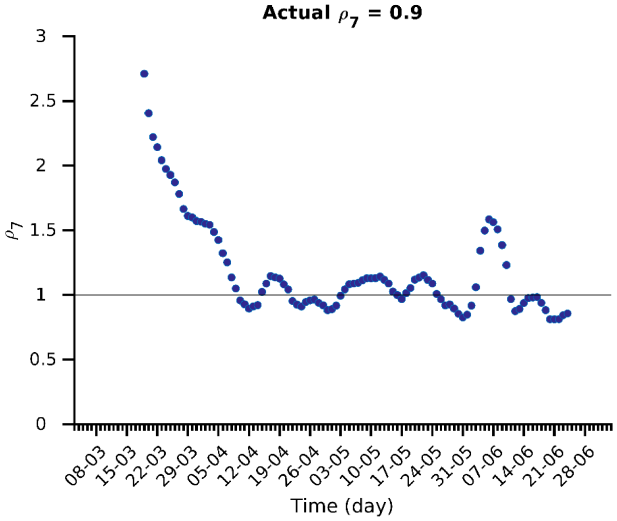
Poland 28-06-2020. Population: 37.8M. Current cumulative incidence: $90/10^5$

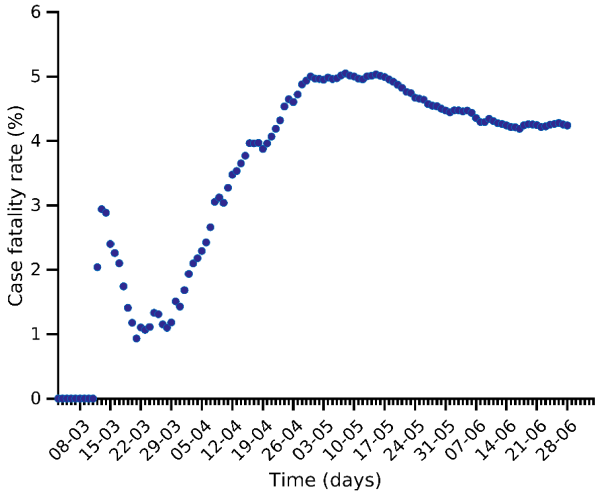


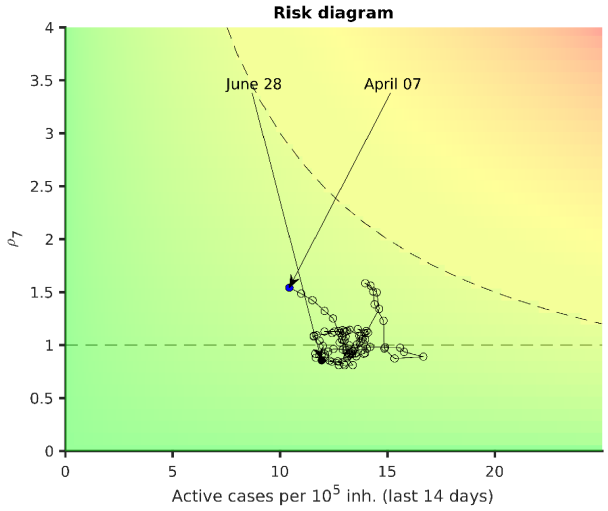


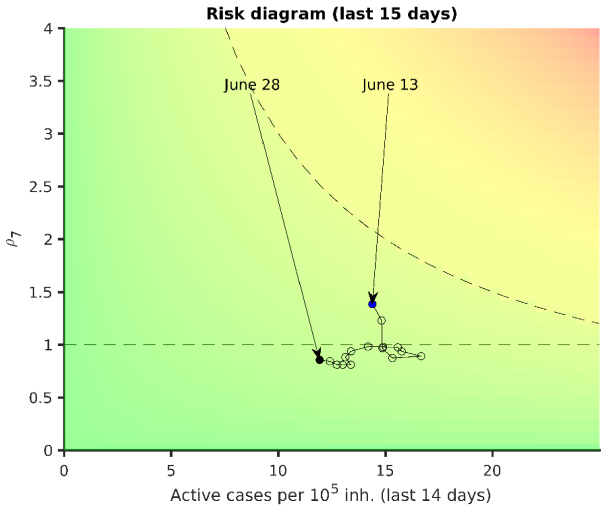




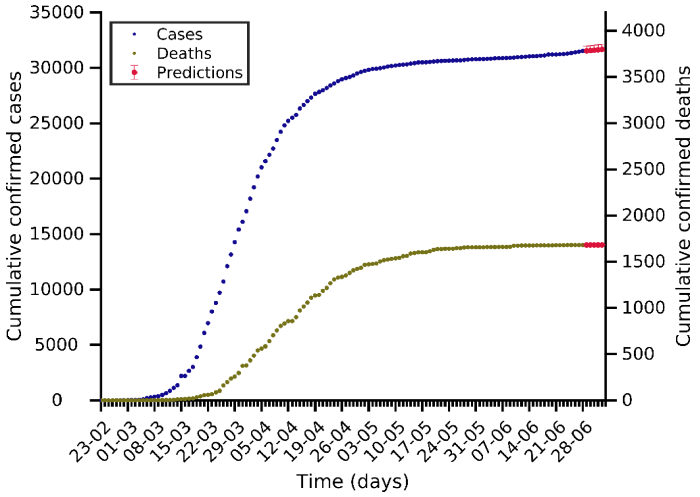


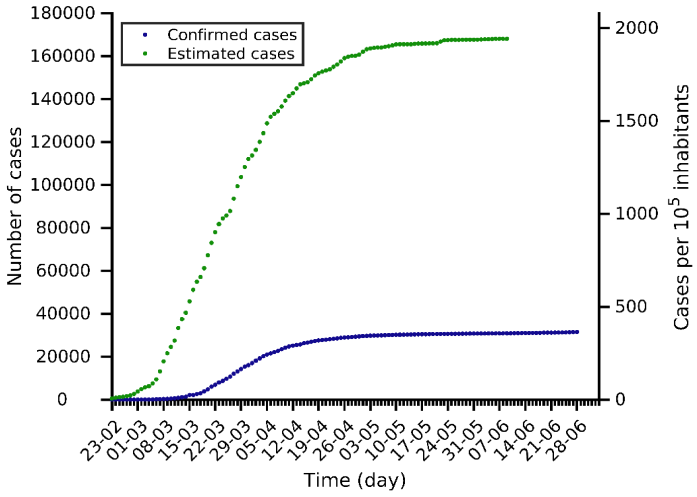


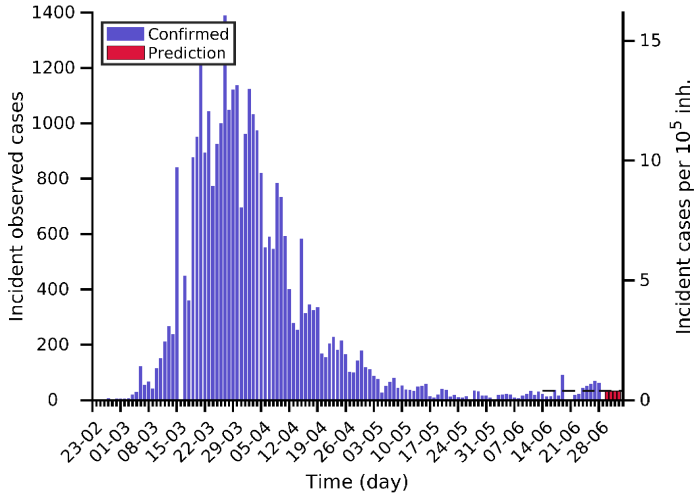


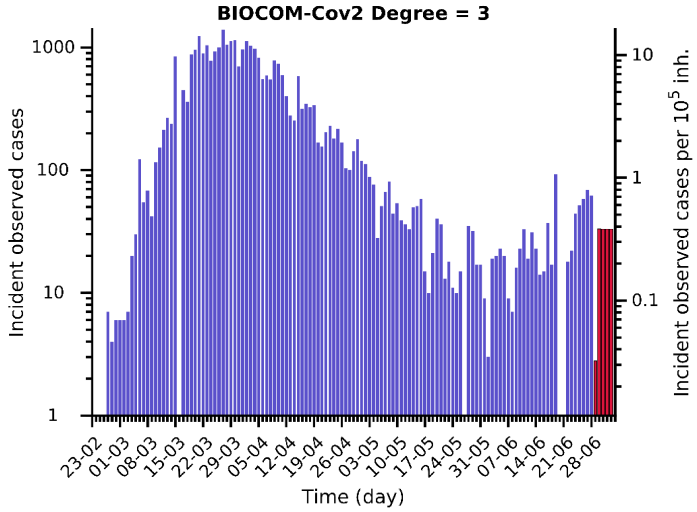


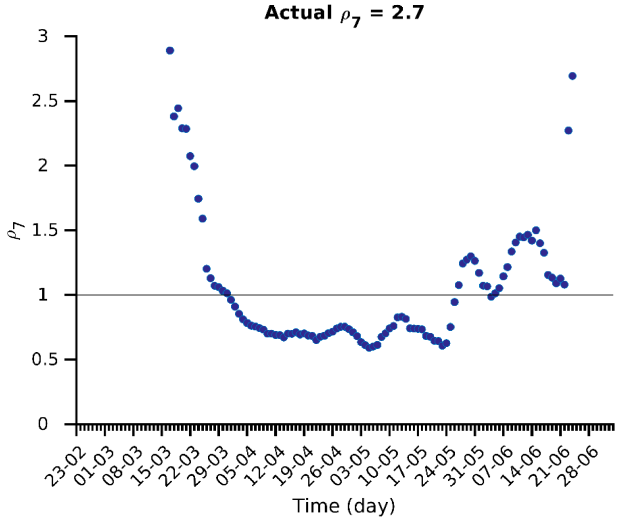
Switzerland 28-06-2020. Population: 8.7M. Current cumulative incidence: 364/10^5

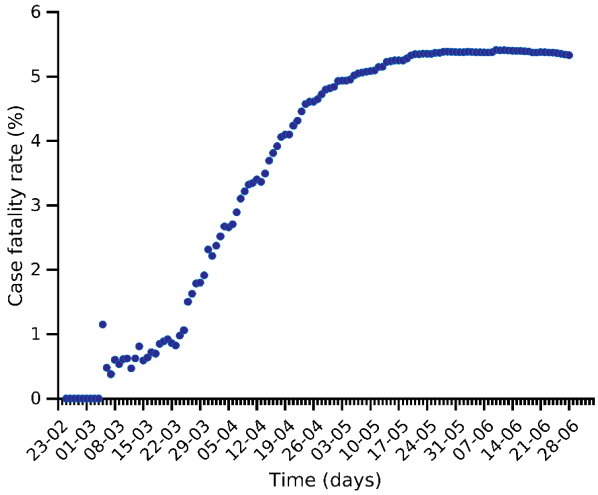


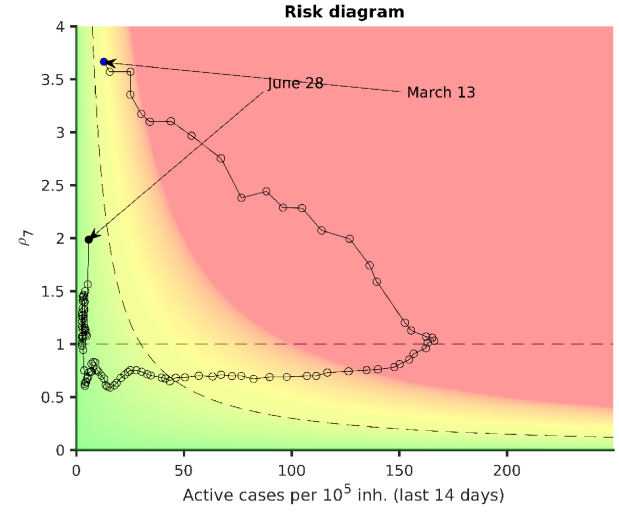


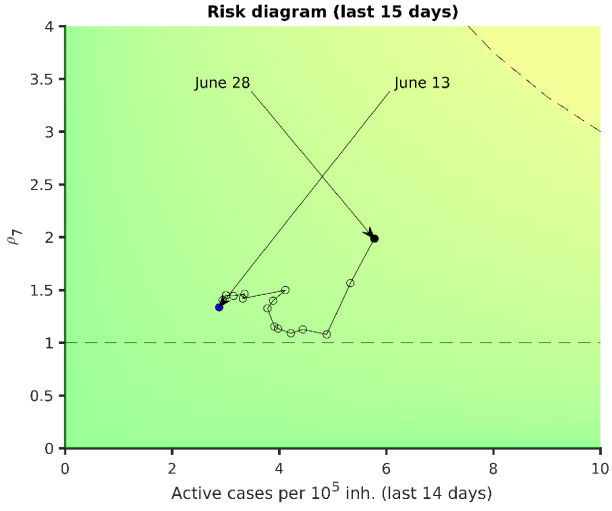




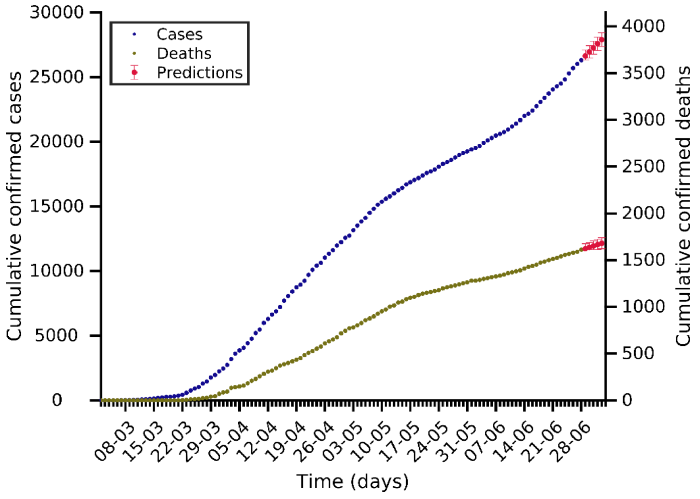


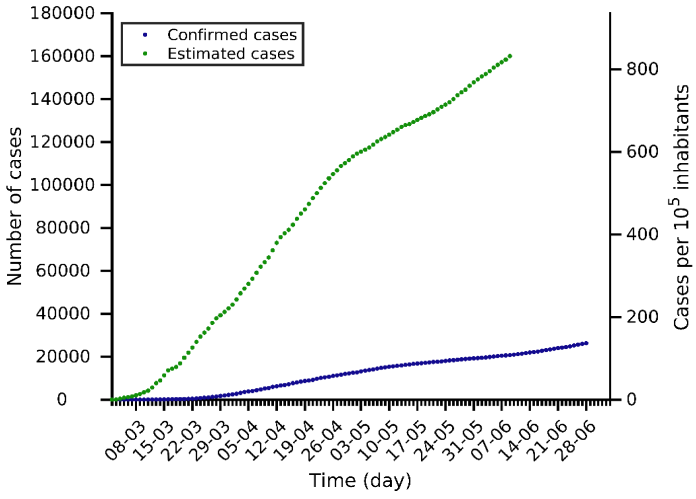


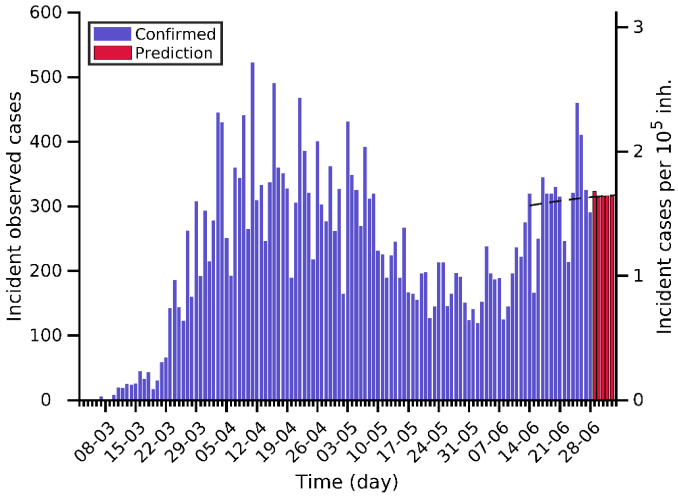


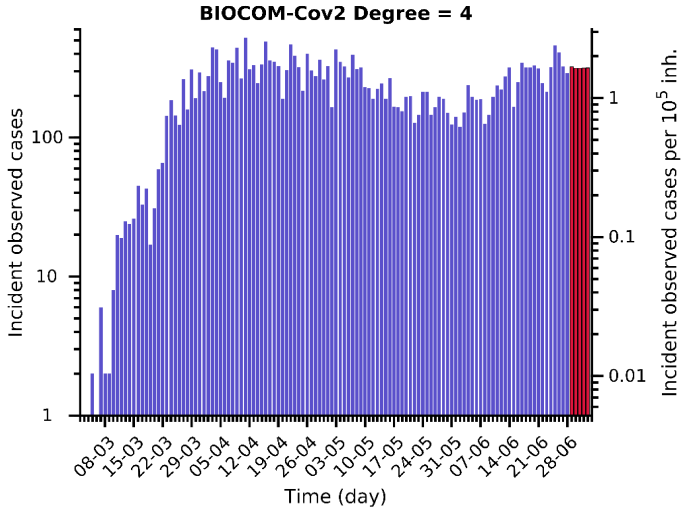


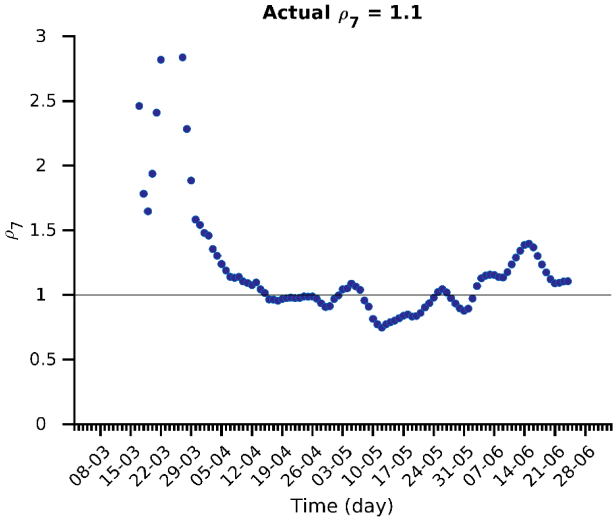
Romania 28-06-2020. Population: 19.2M. Current cumulative incidence: 137/10^5

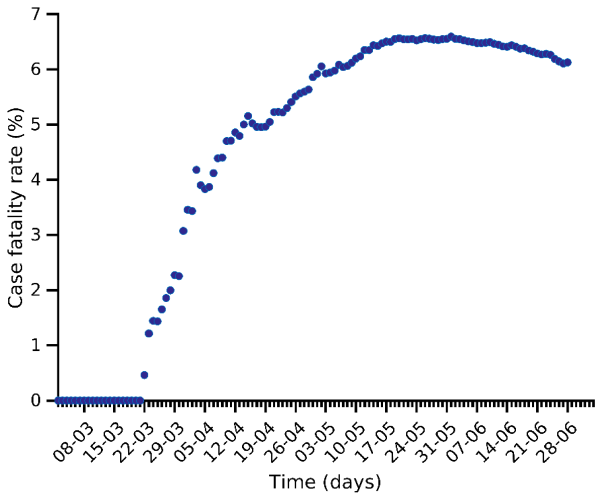


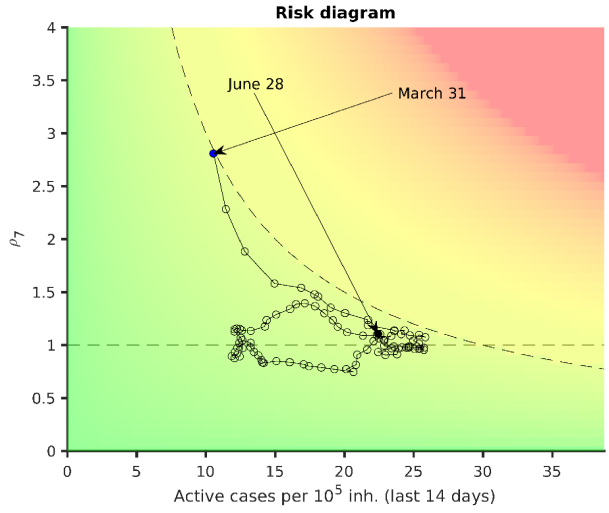


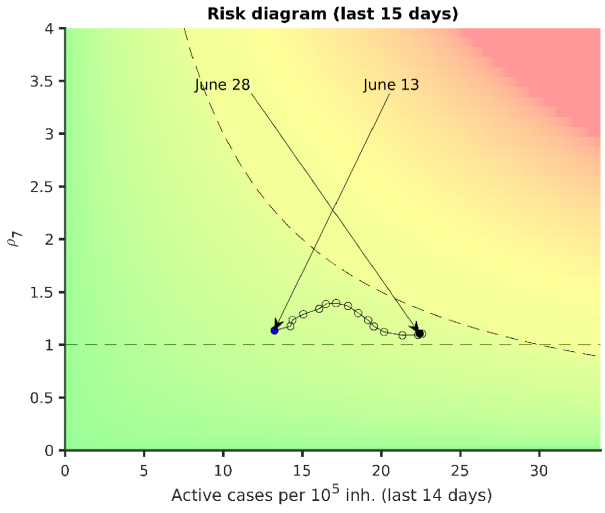




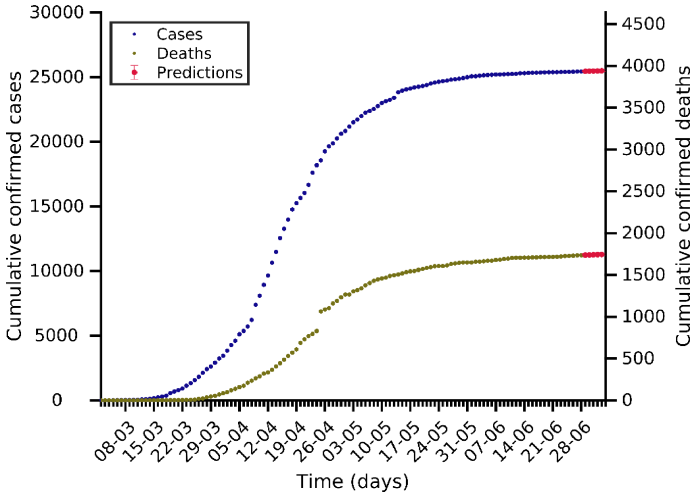


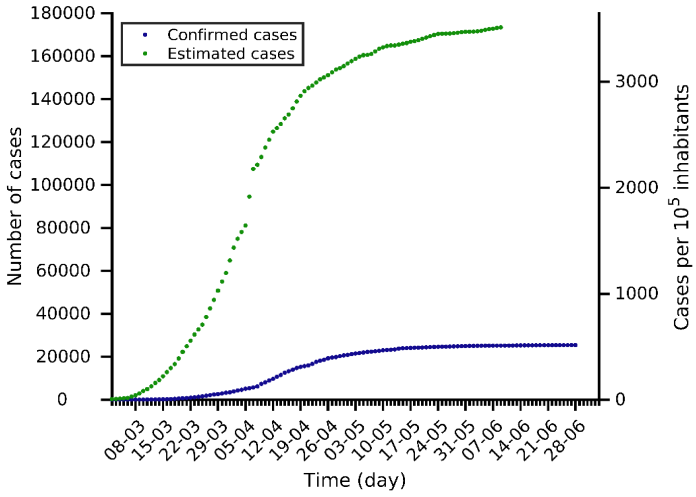


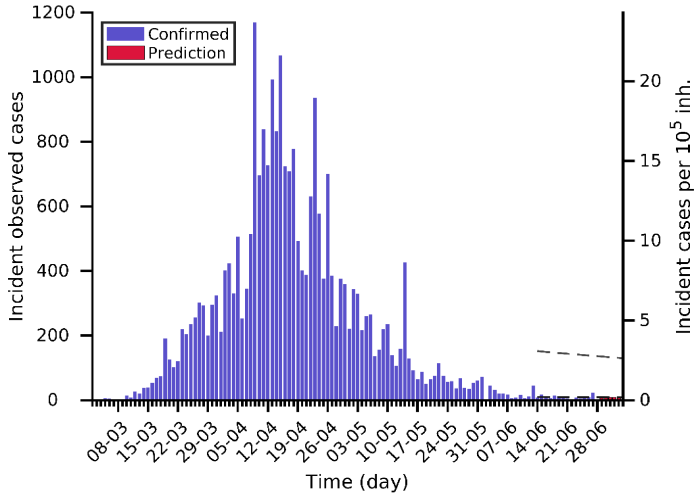


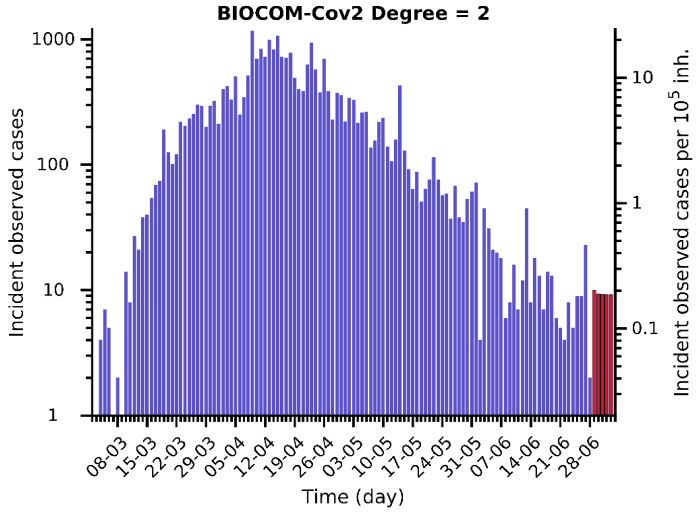


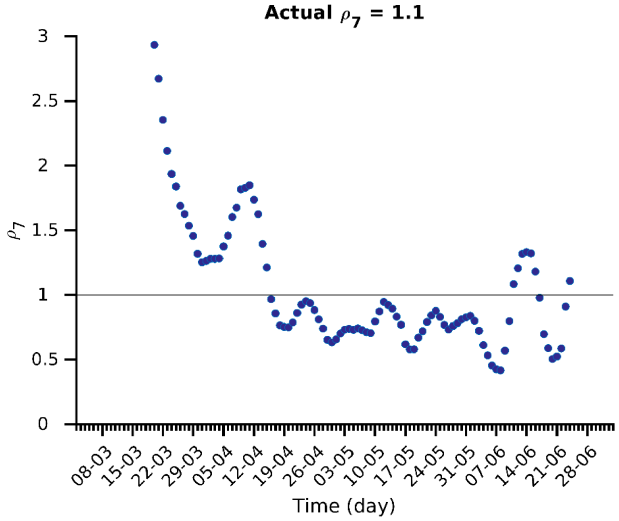
Ireland 28-06-2020. Population: 4.9M. Current cumulative incidence: 515/10⁵

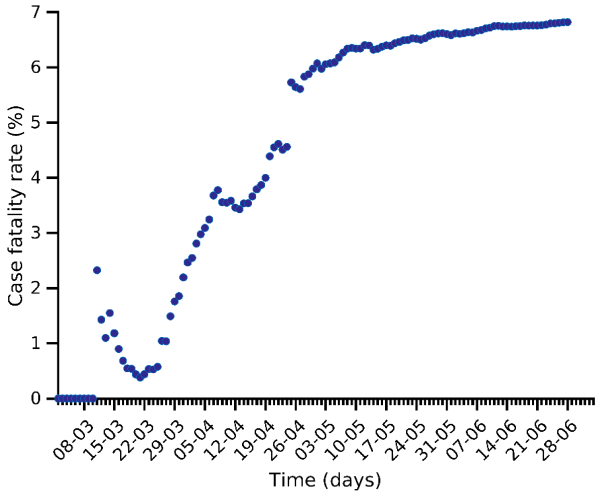


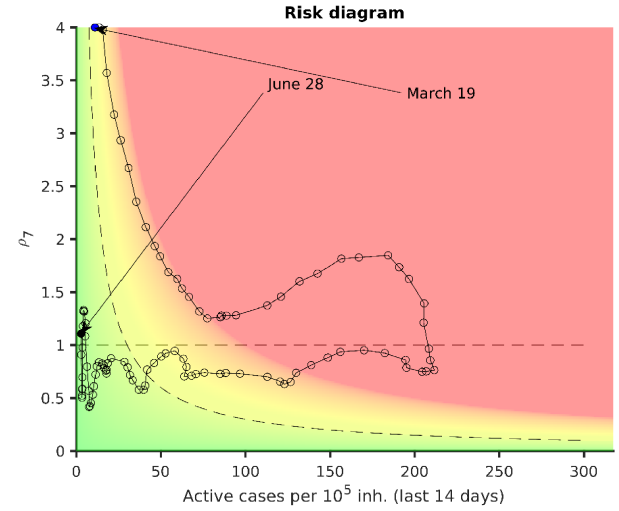


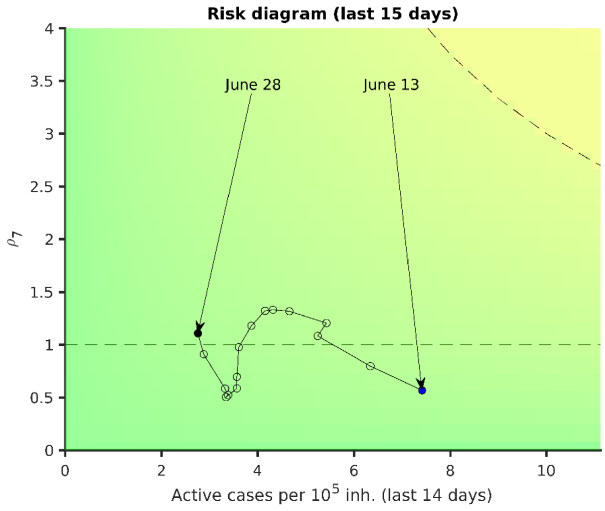




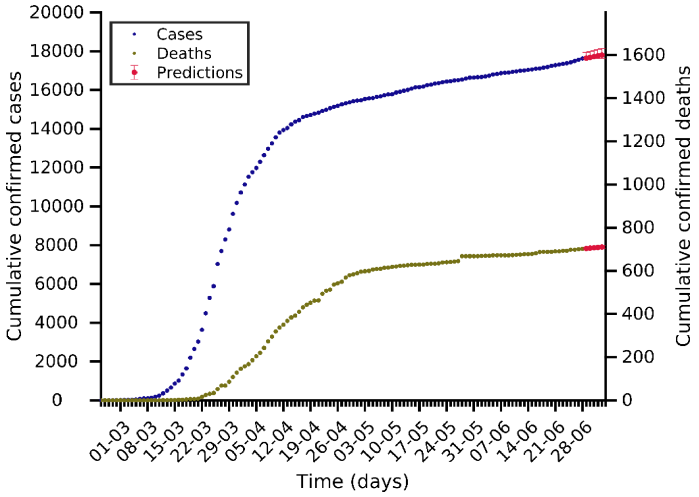


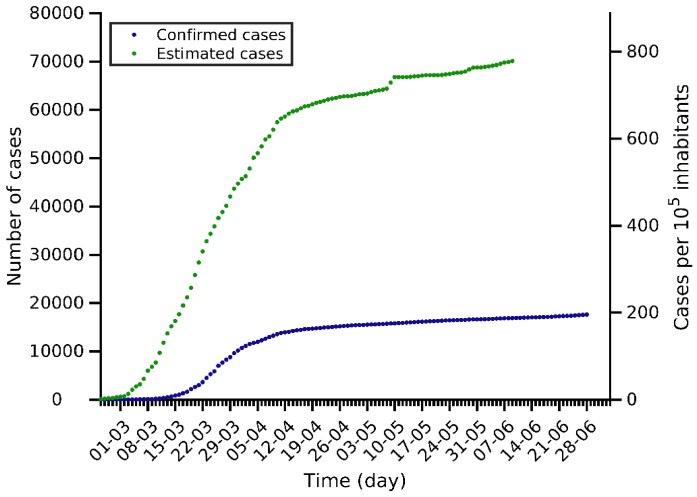


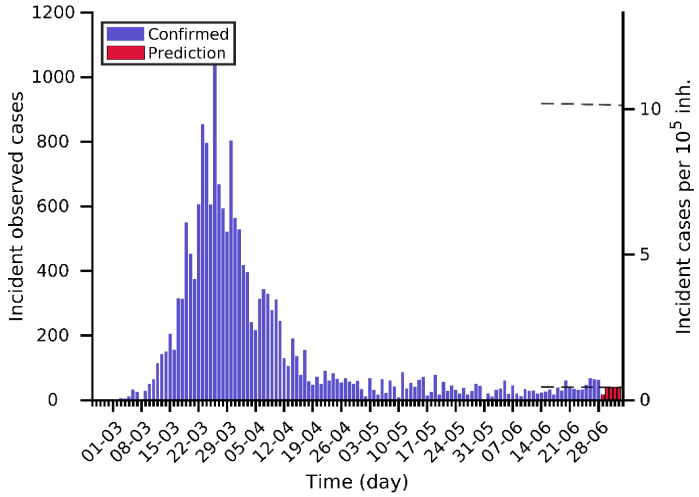


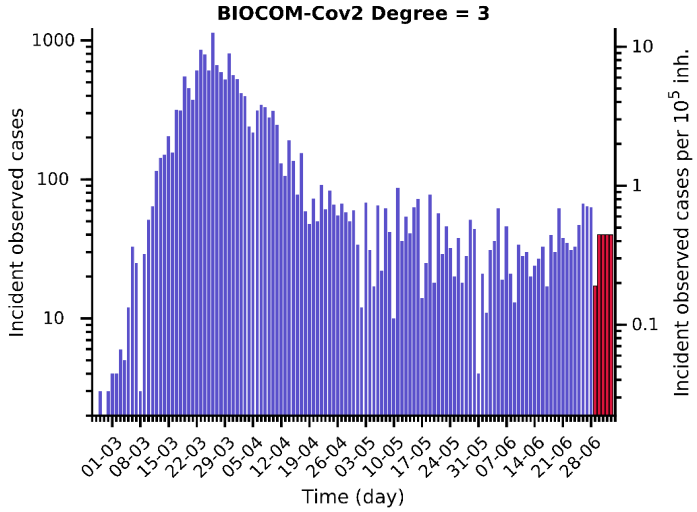


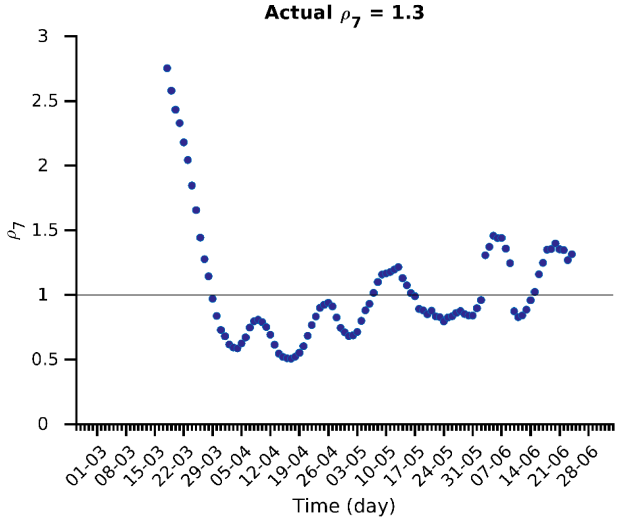
Austria 28-06-2020. Population: 9.0M. Current cumulative incidence: 196/10⁵

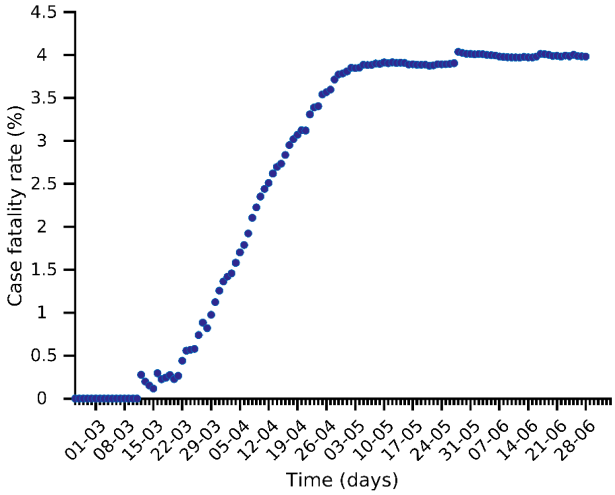


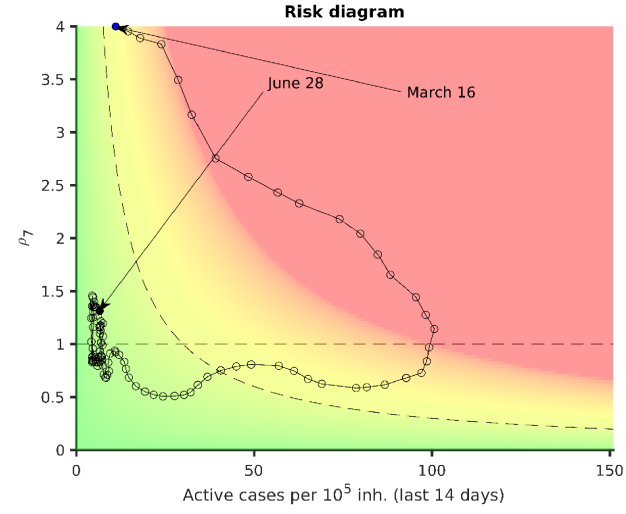


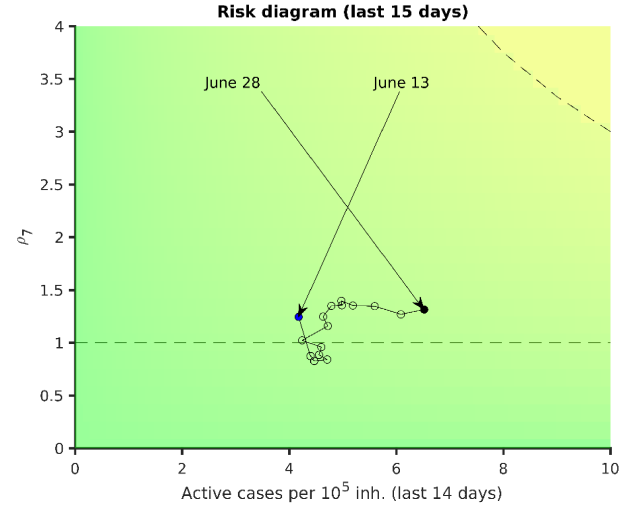




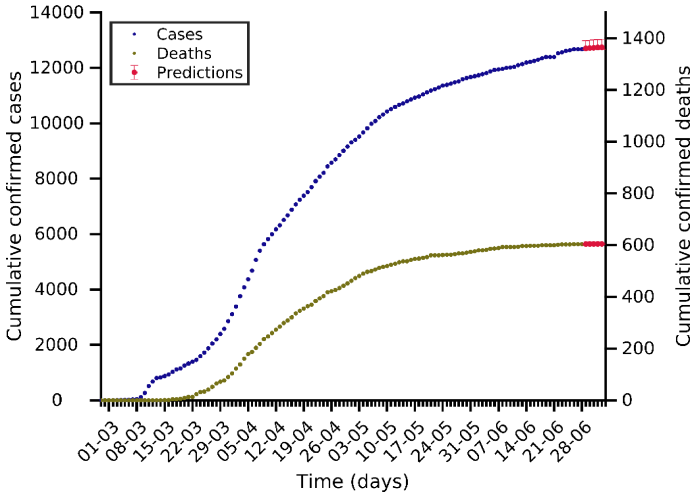


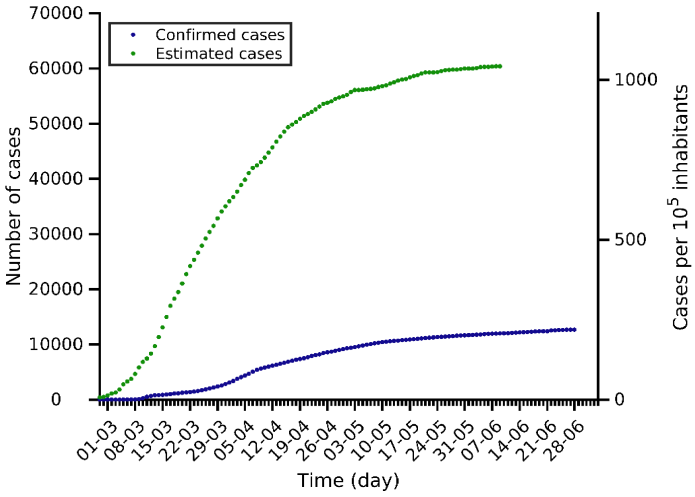


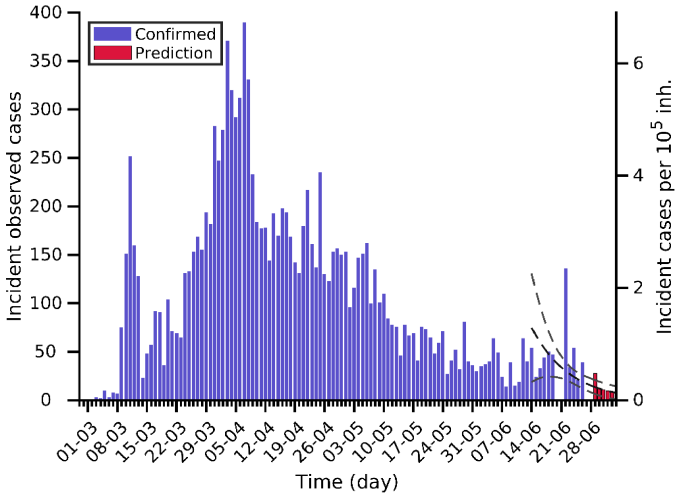


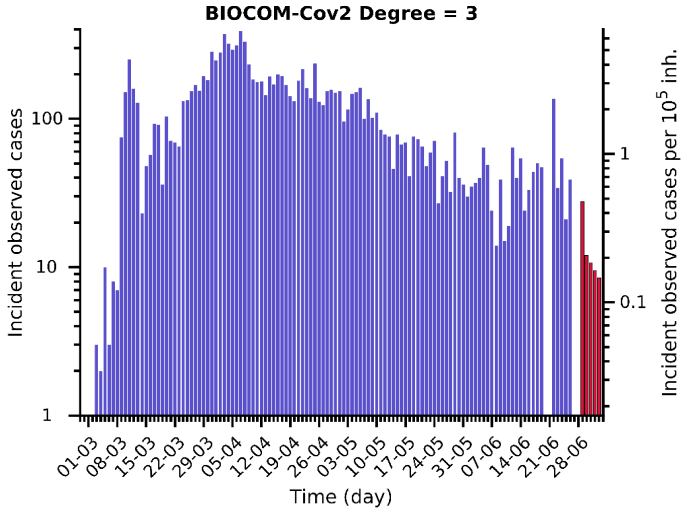


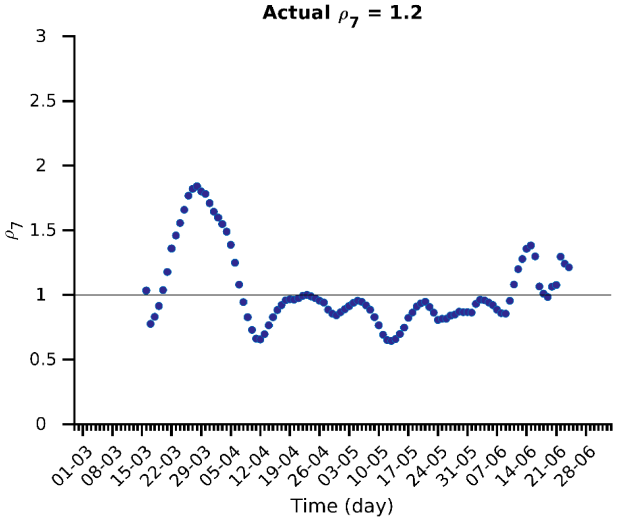
Denmark 28-06-2020. Population: 5.8M. Current cumulative incidence: 219/10^5

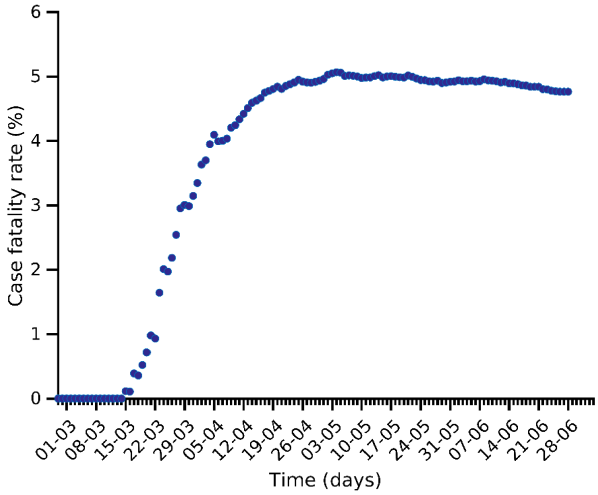


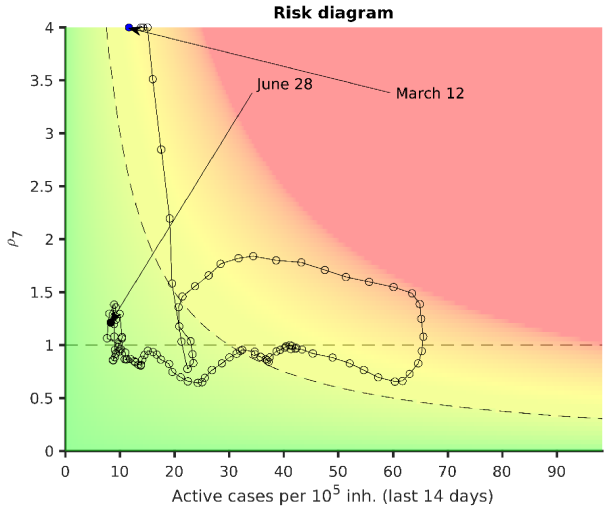


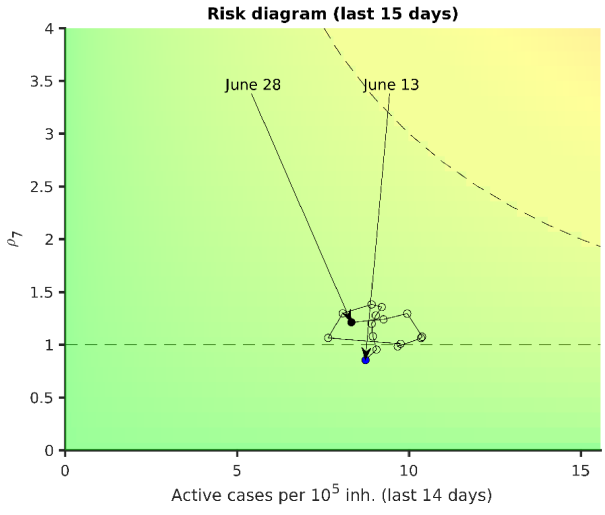




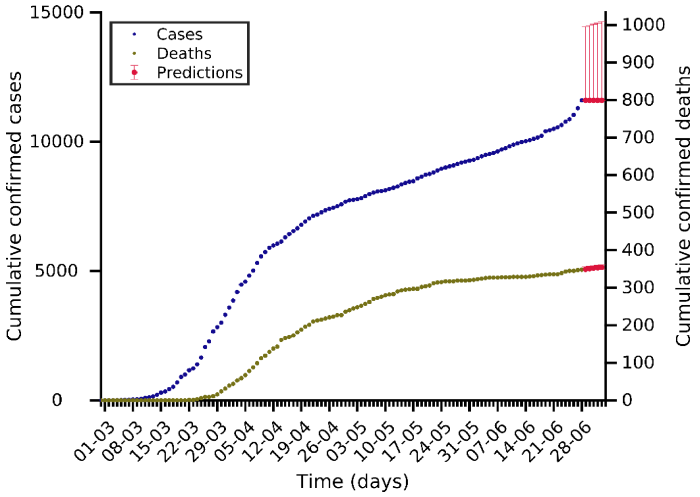


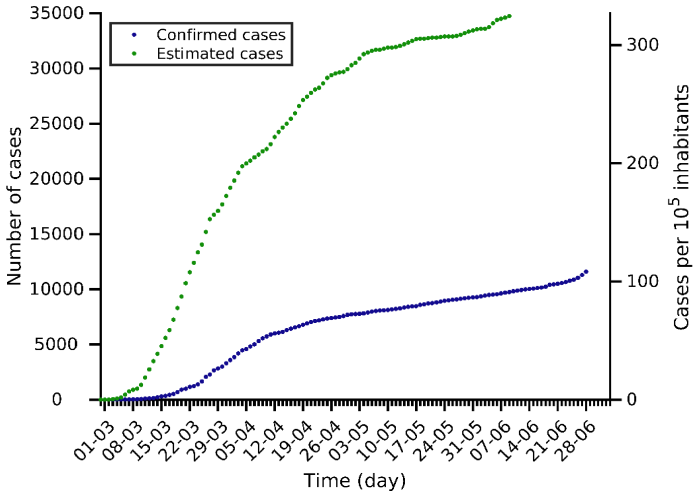


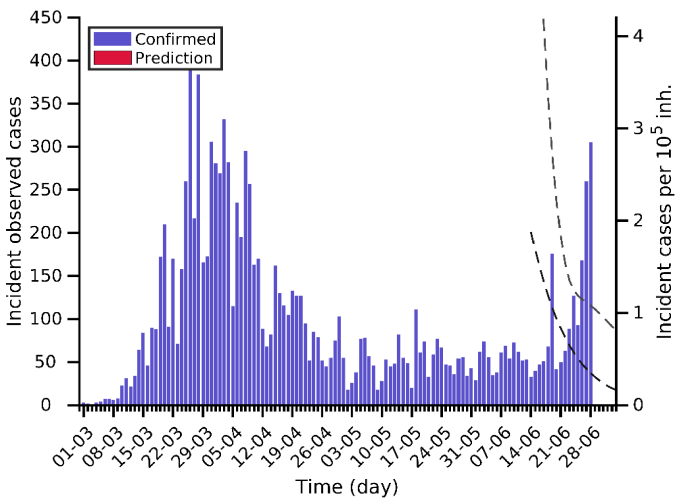


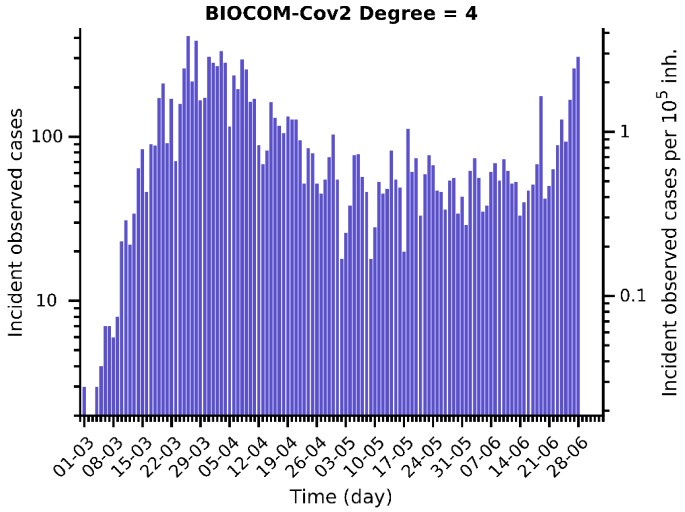


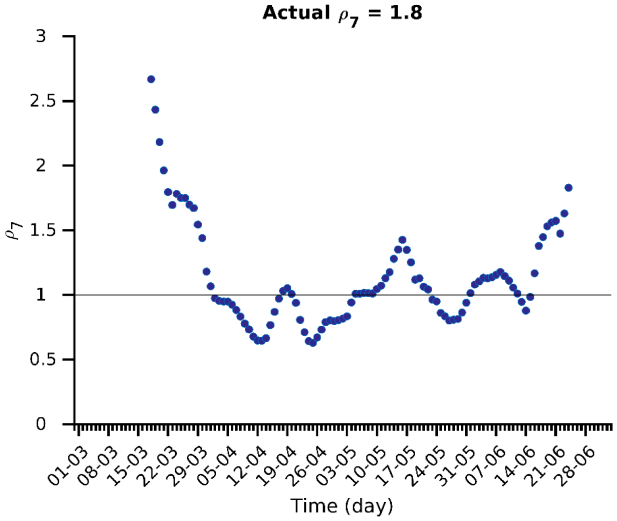
Czech Rep 28-06-2020. Population: 10.7M. Current cumulative incidence: 108/10^5

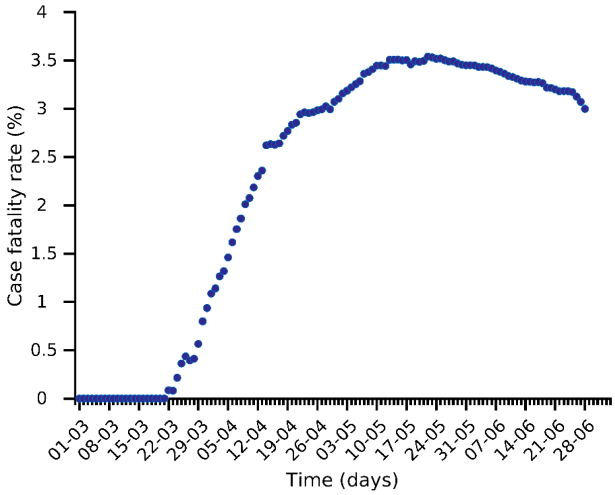


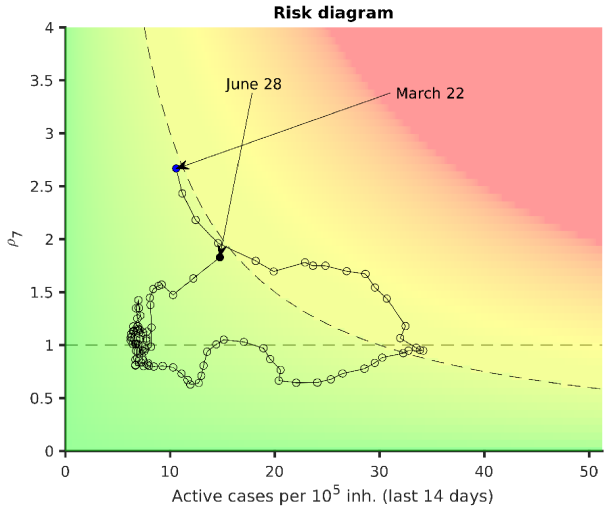


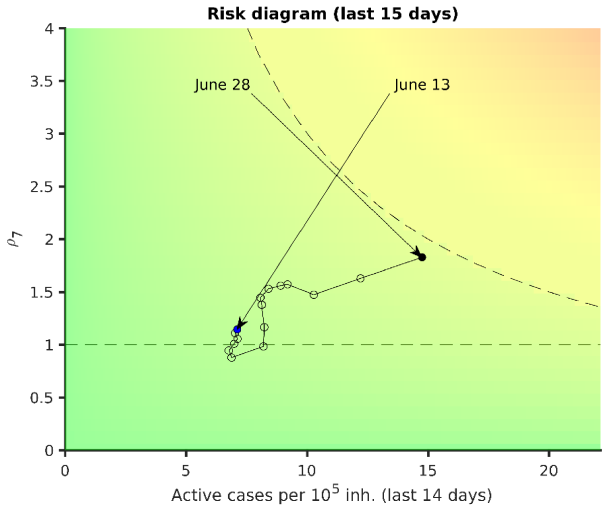




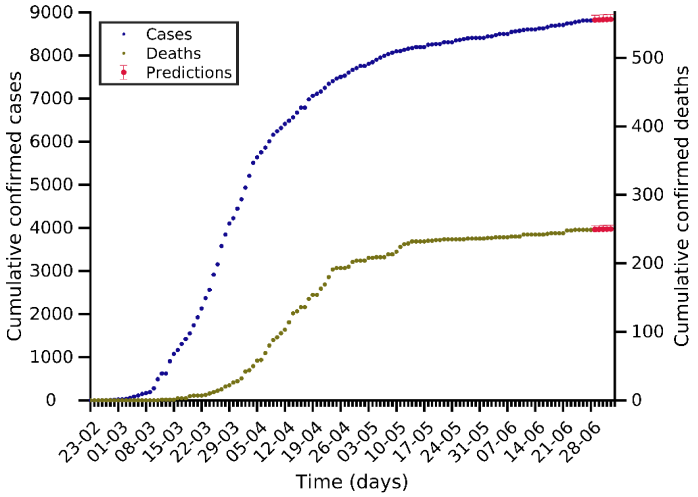


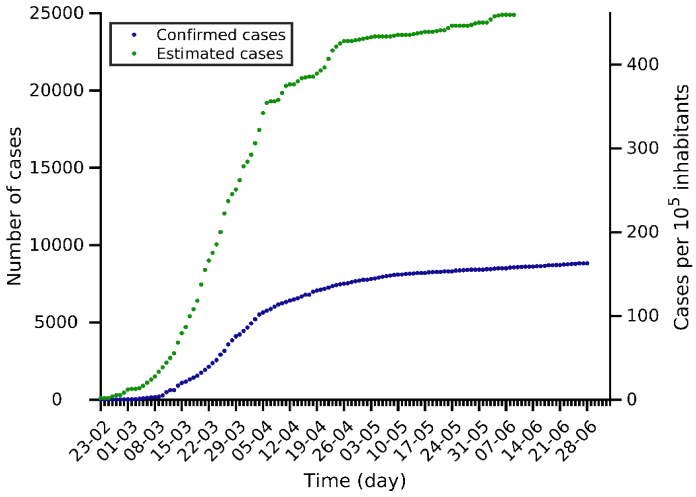


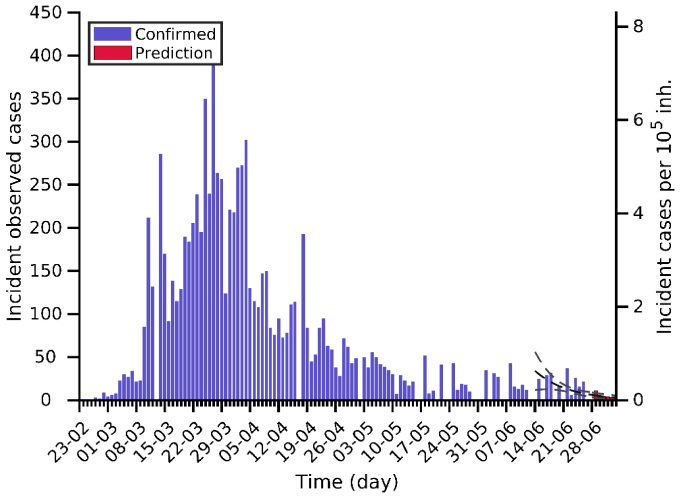


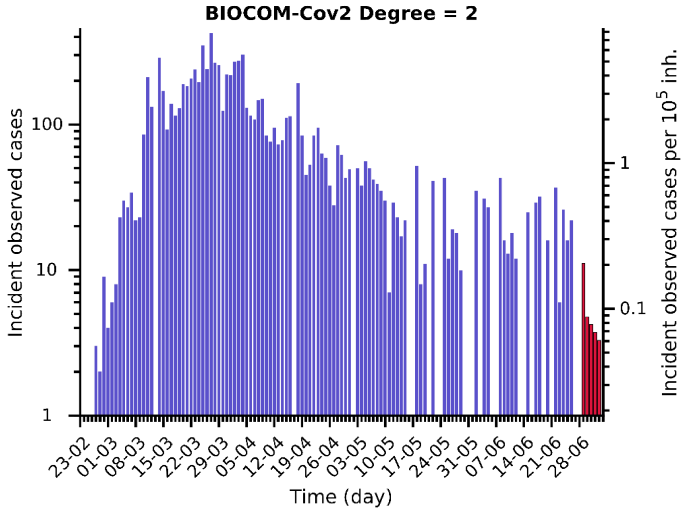


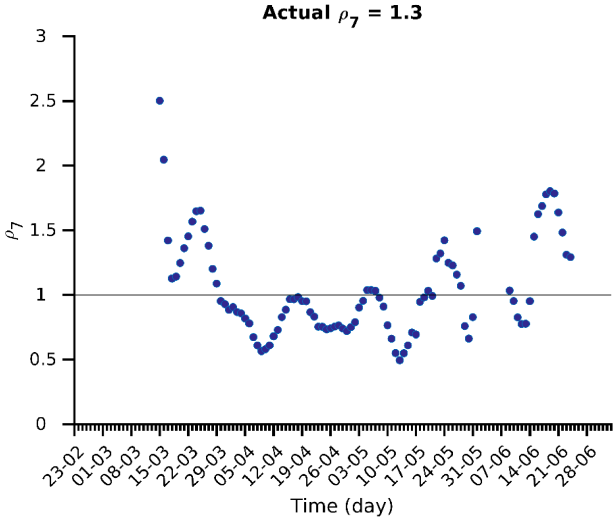
Norway 28-06-2020. Population: 5.4M. Current cumulative incidence: 163/10⁵

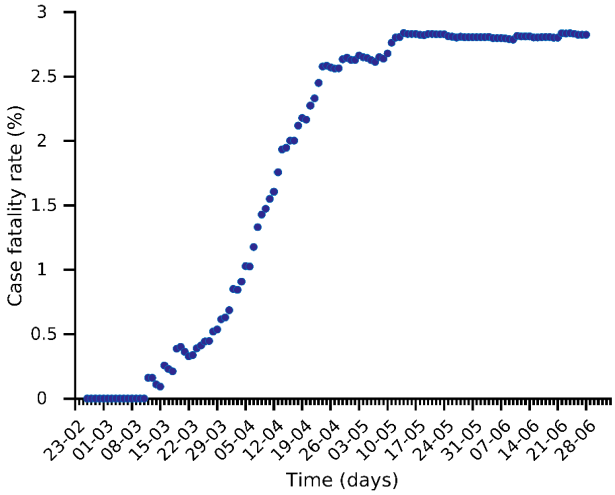


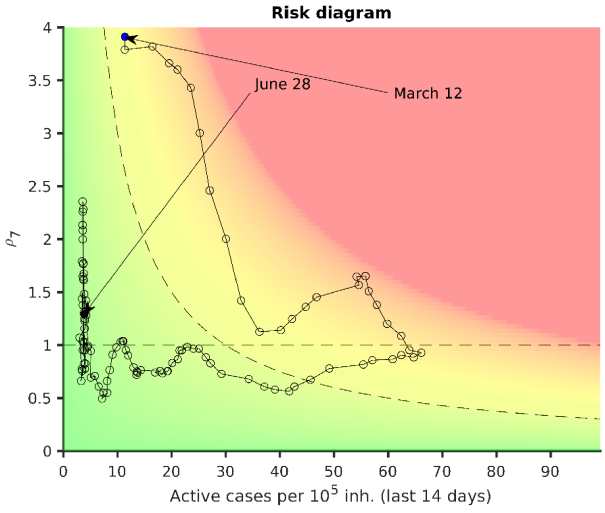


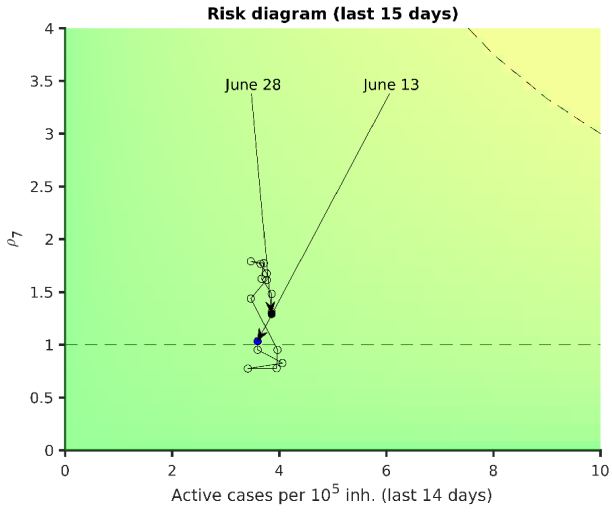




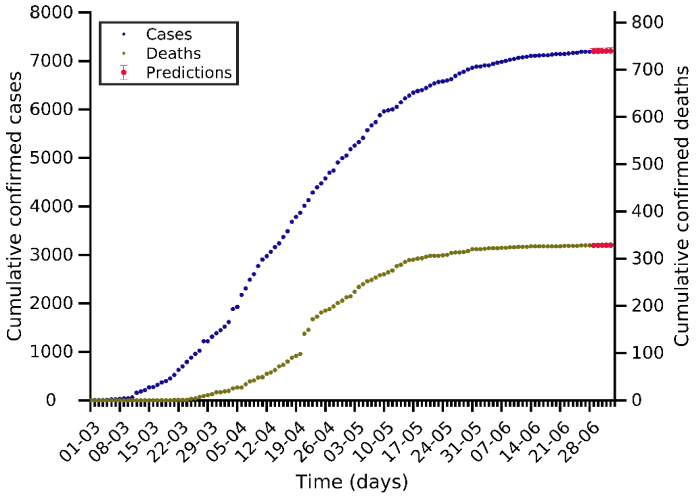


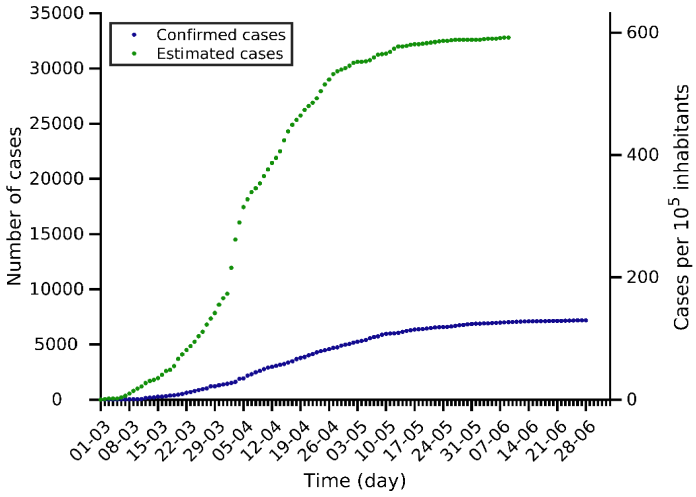


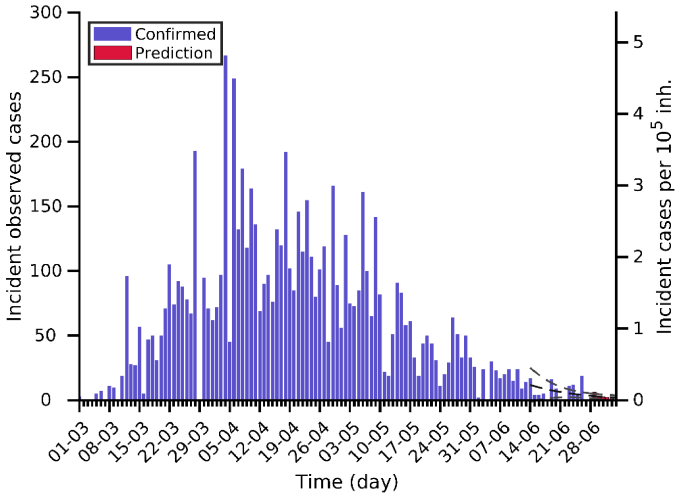


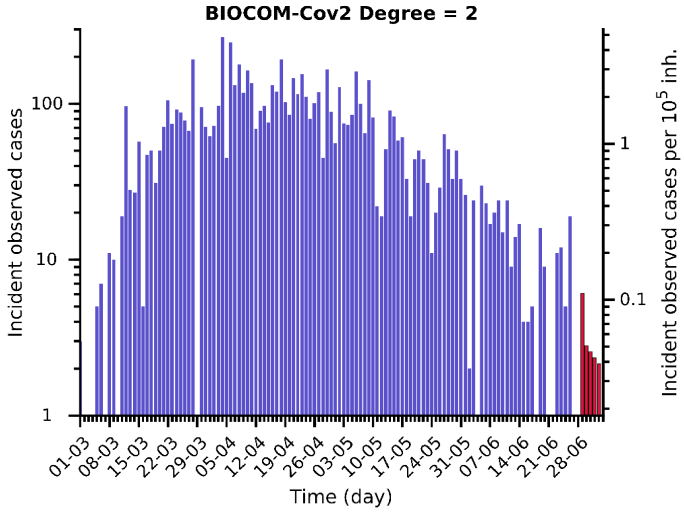


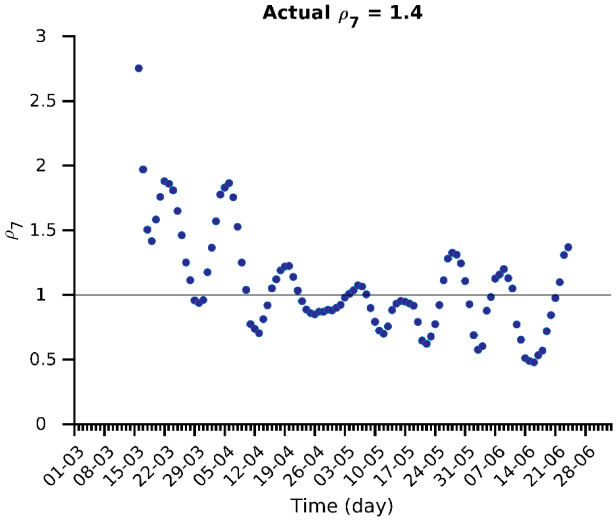
Finland 28-06-2020. Population: 5.5M. Current cumulative incidence: 130/10⁵

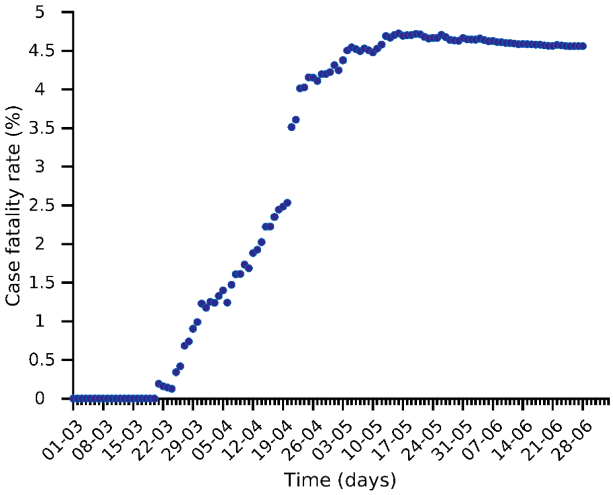


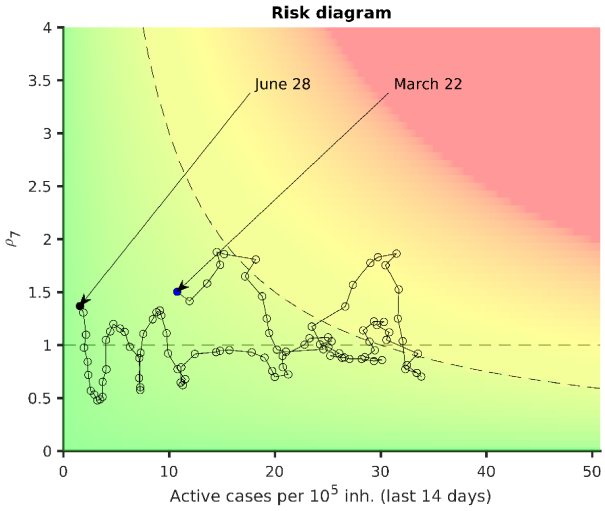


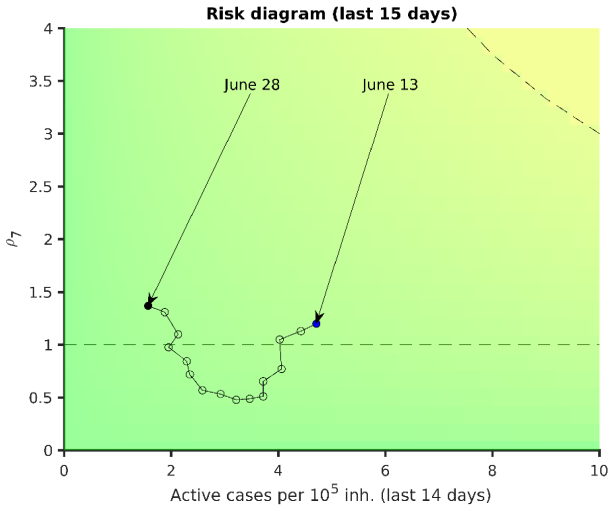




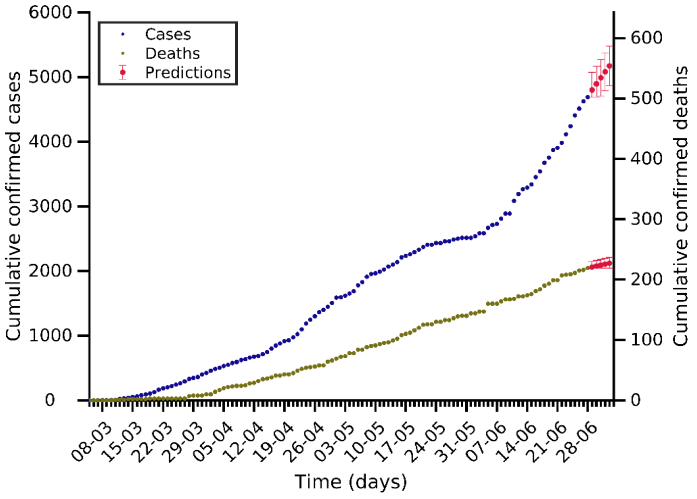


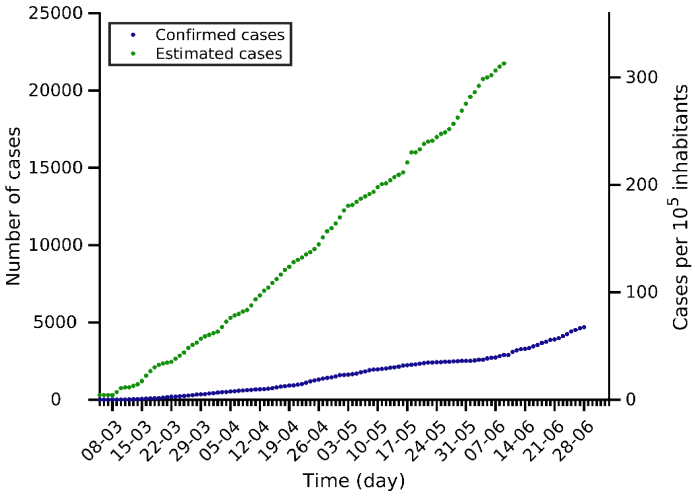


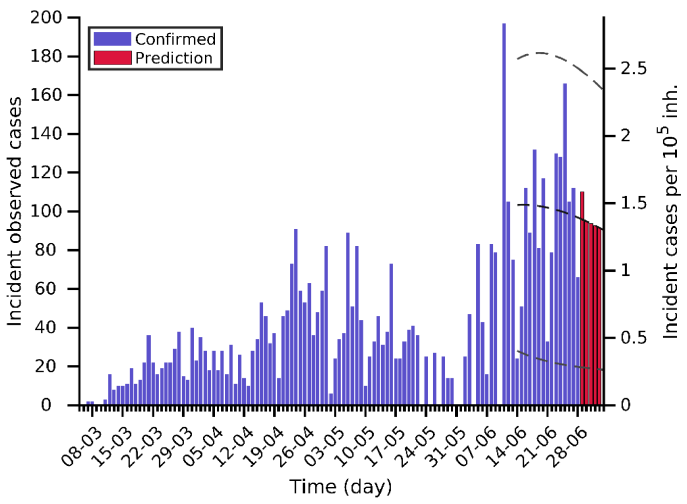


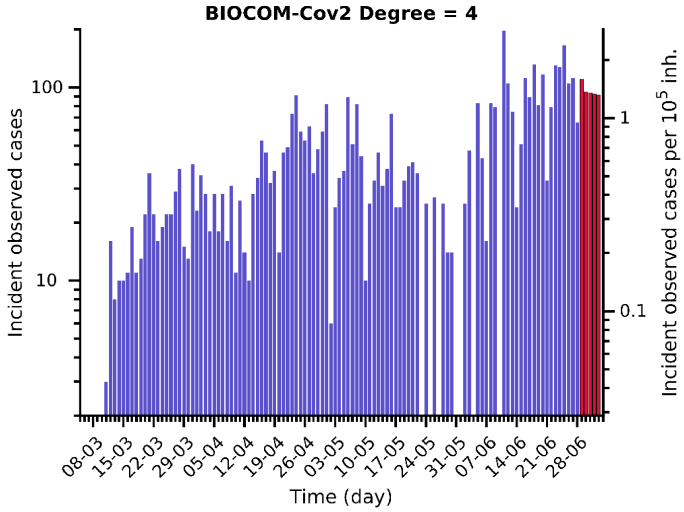


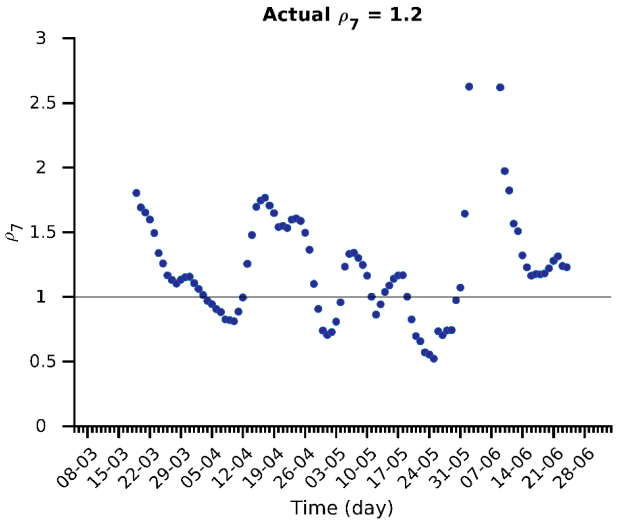
Bulgaria 28-06-2020. Population: 6.9M. Current cumulative incidence: 68/10^5

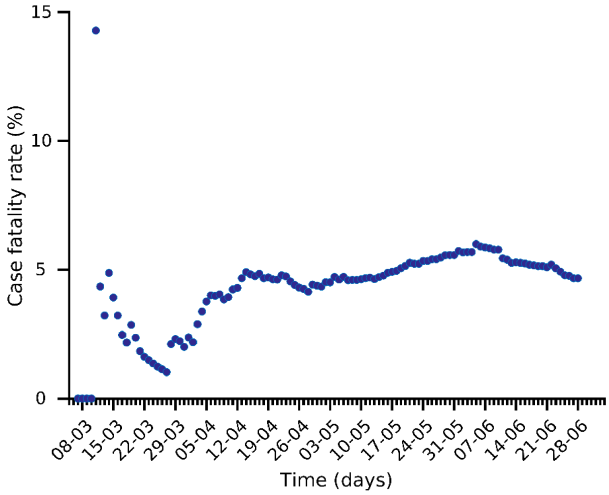


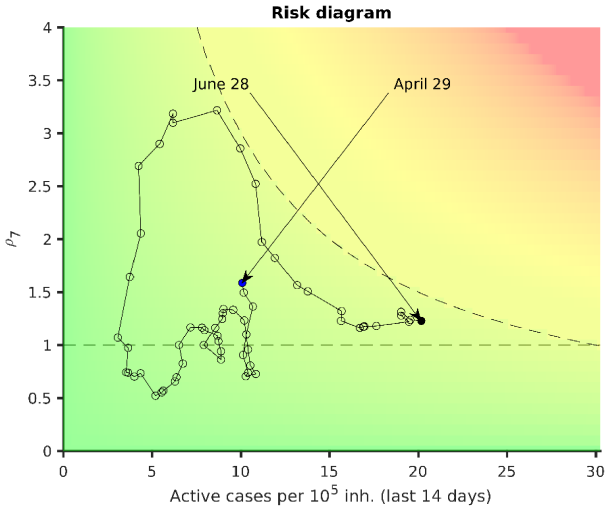


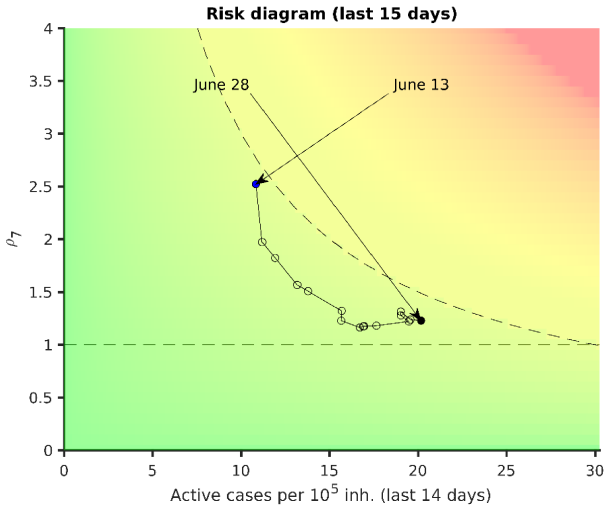




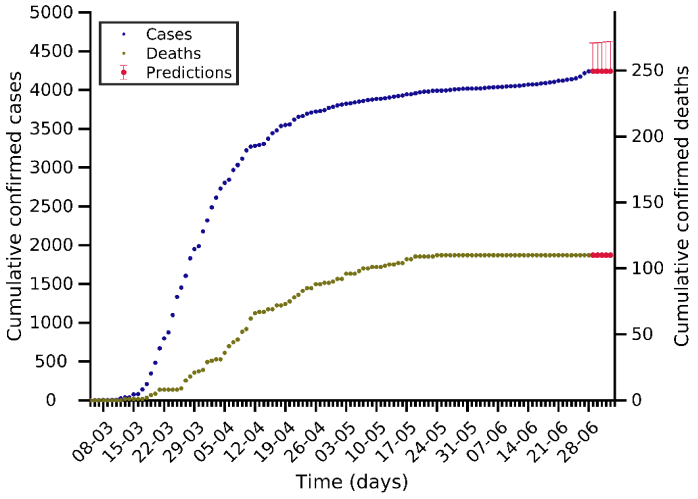


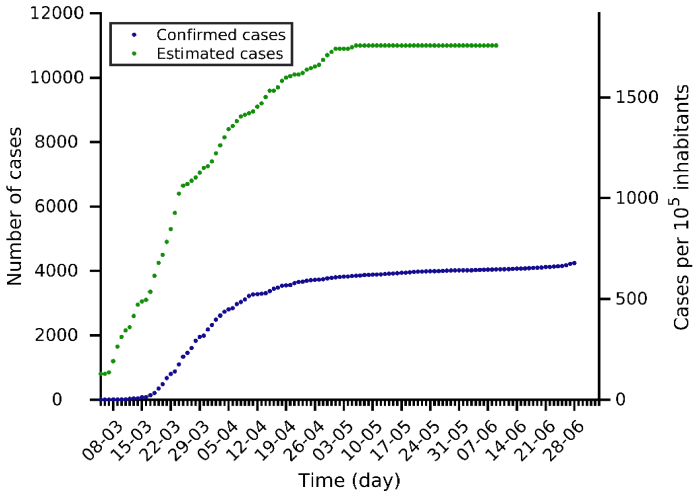


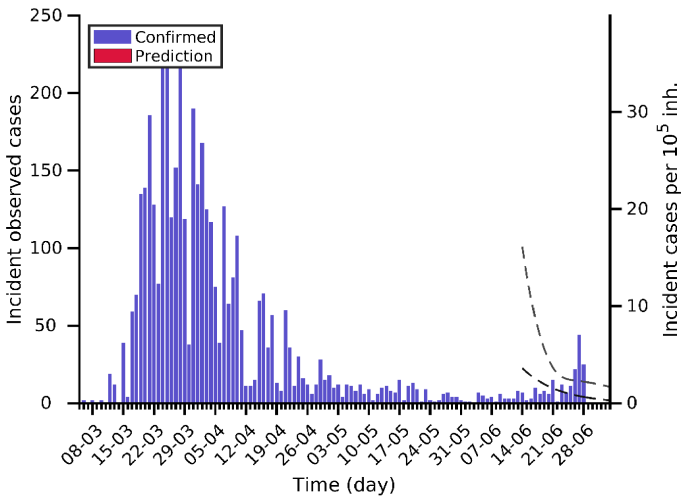


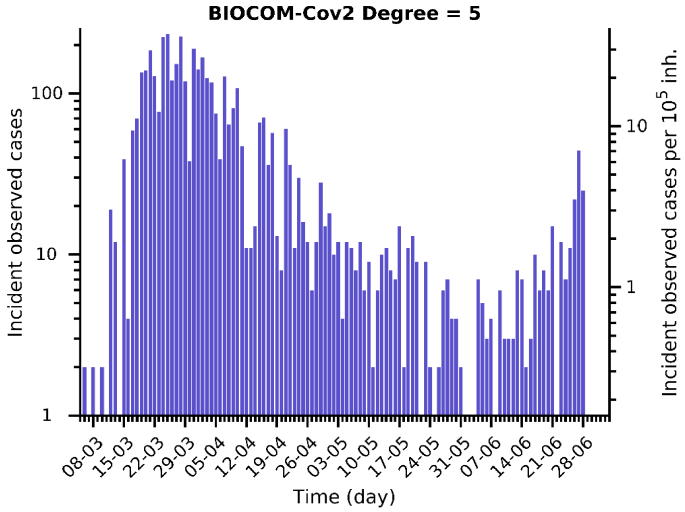


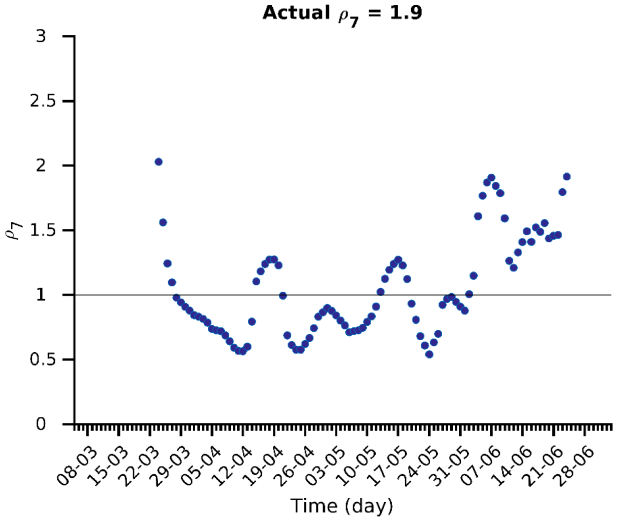
Luxembourg 28-06-2020. Population: 0.6M. Current cumulative incidence: 678/10^5

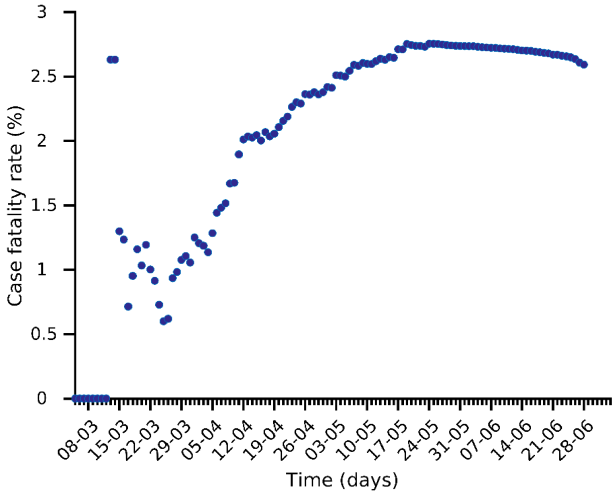


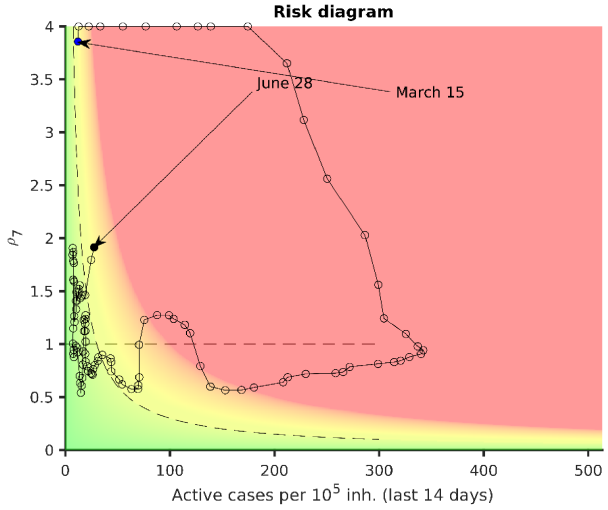


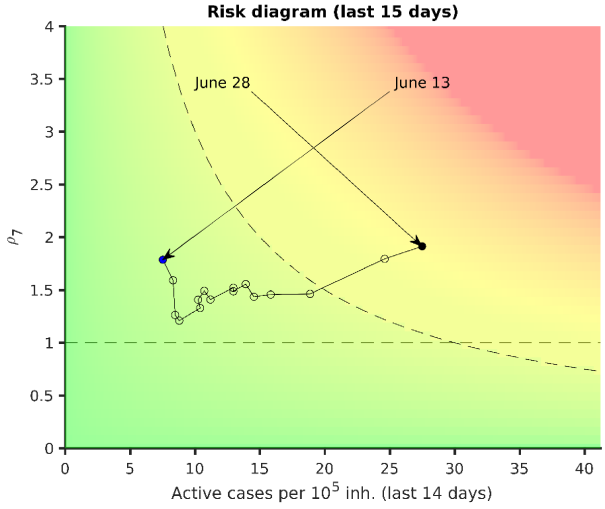




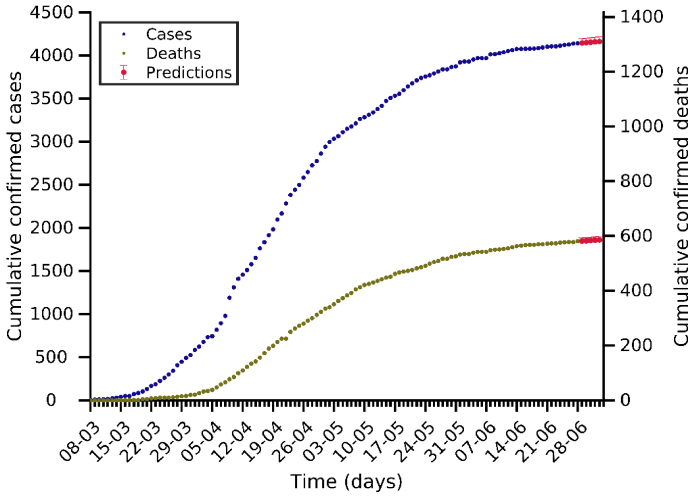


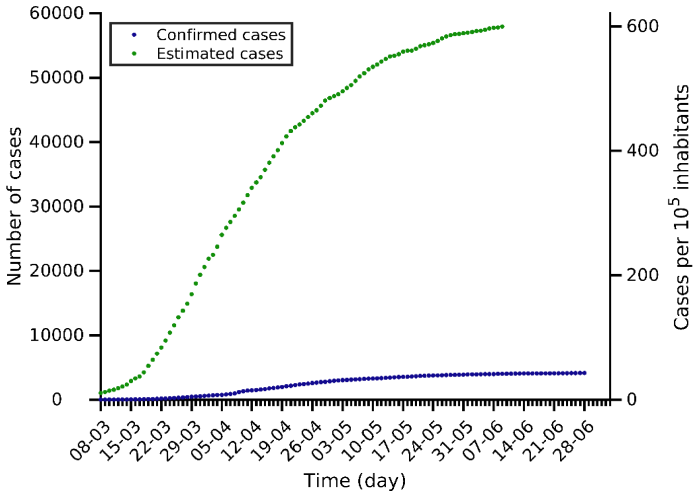


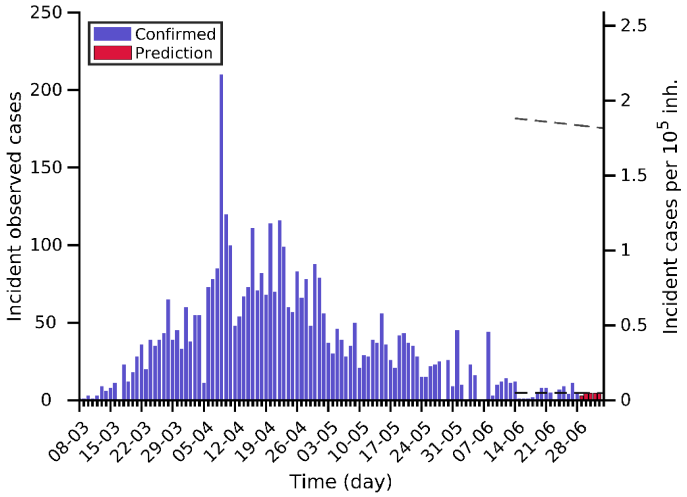


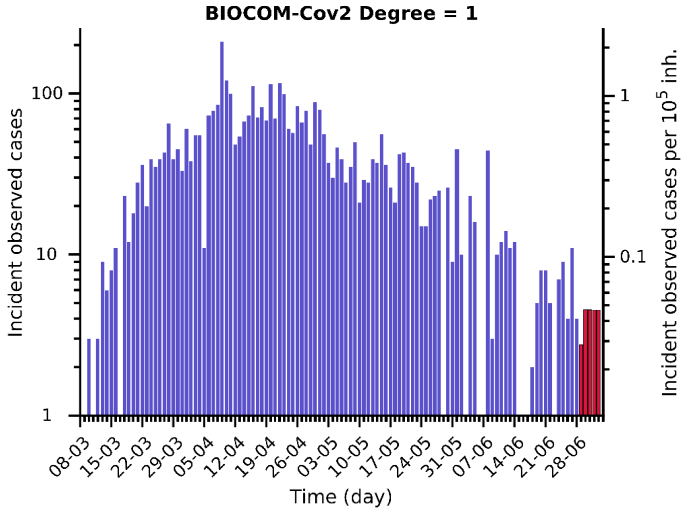


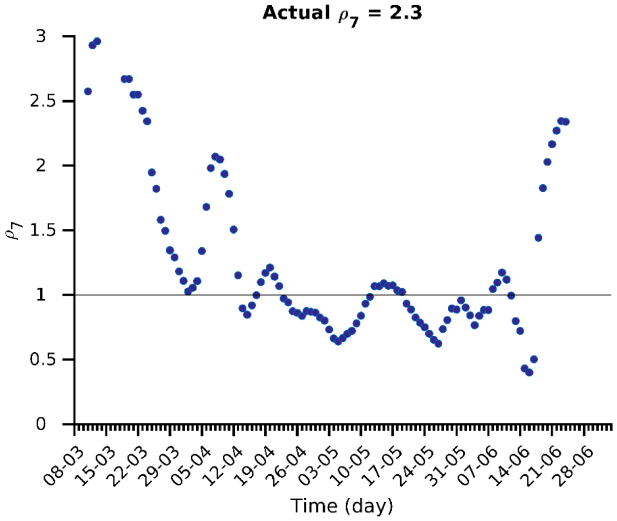
Hungary 28-06-2020. Population: 9.7M. Current cumulative incidence: $43/10^5$

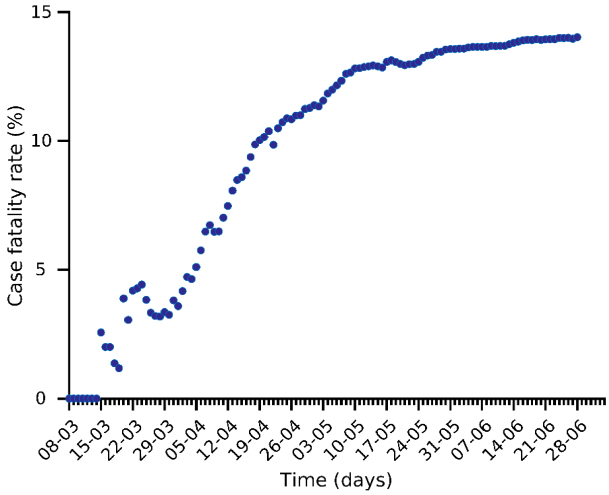


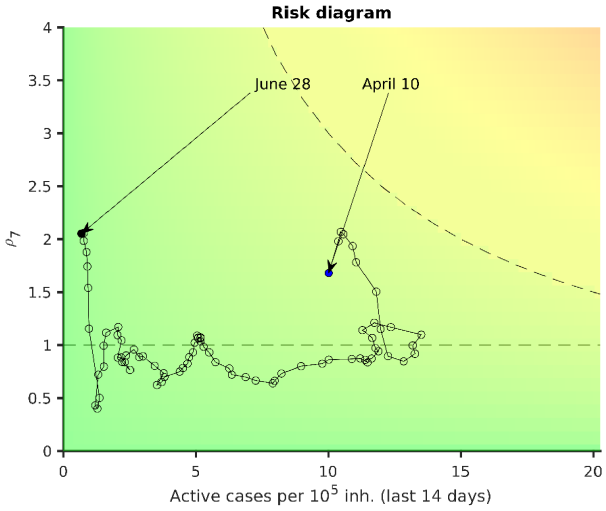


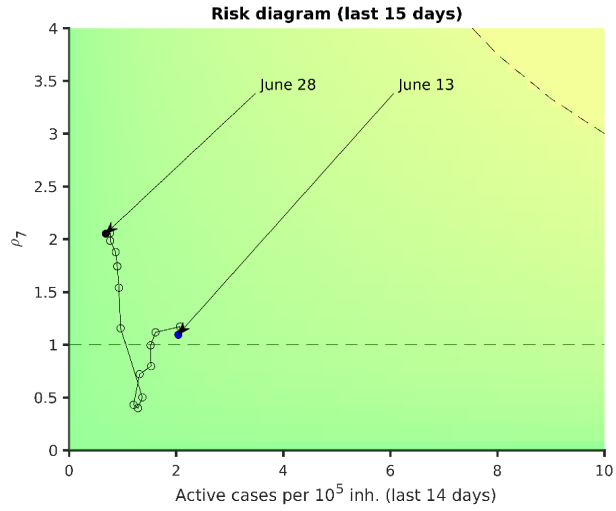




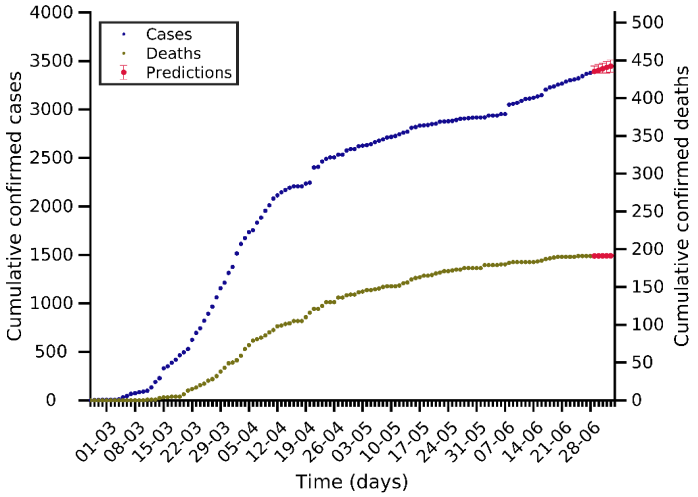


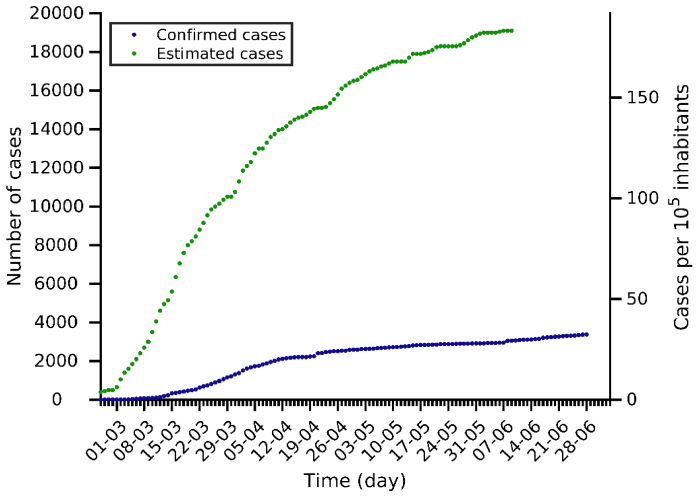


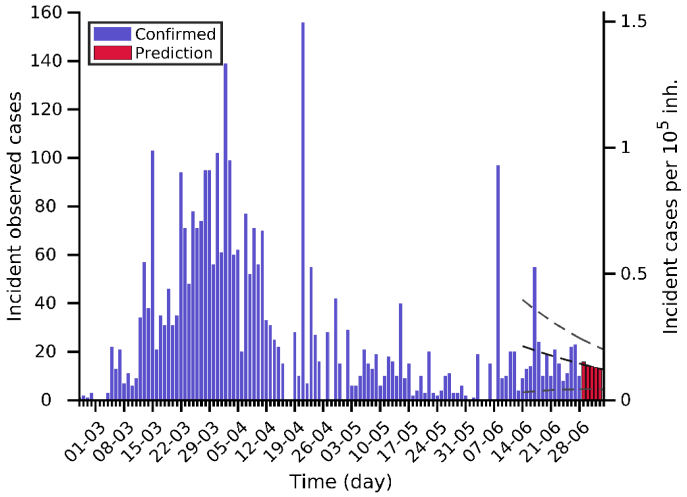


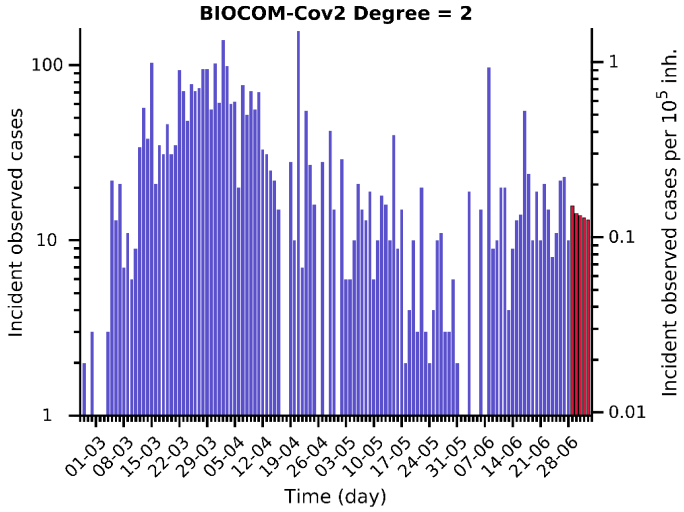


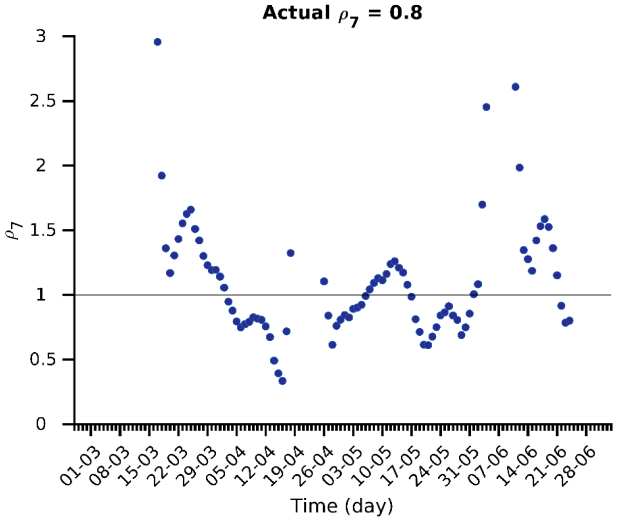
Greece 28-06-2020. Population: 10.4M. Current cumulative incidence: $32/10^5$

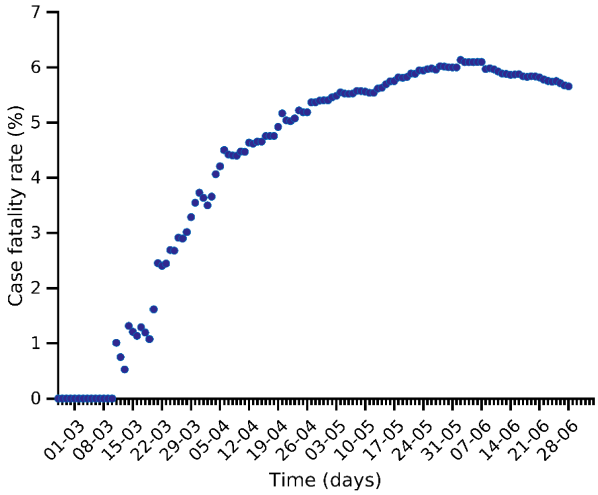


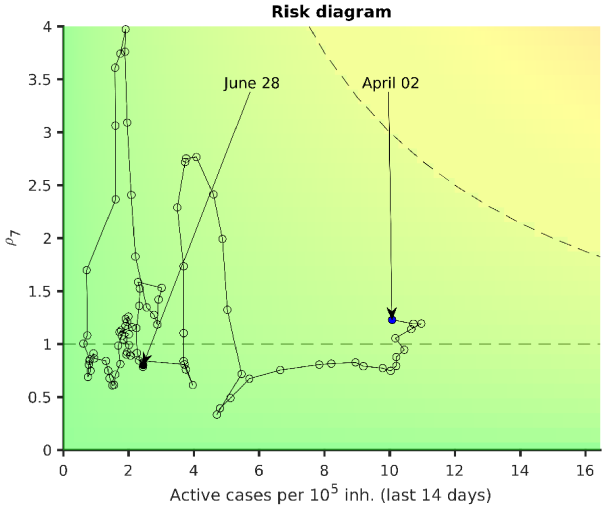


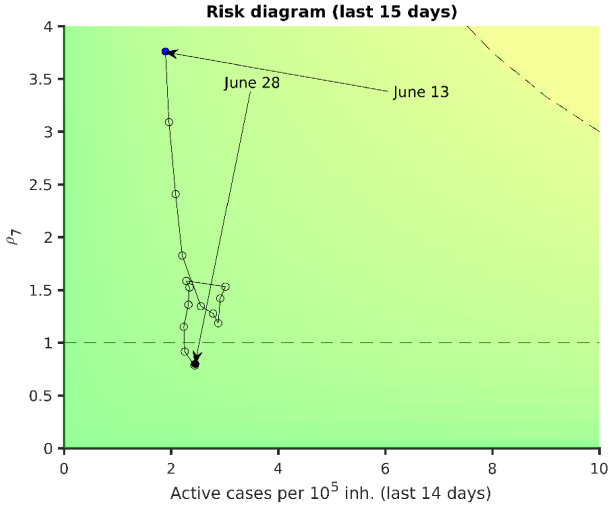




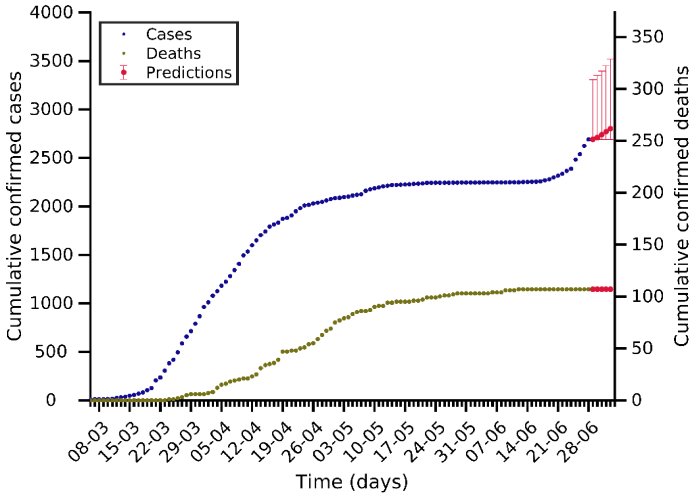


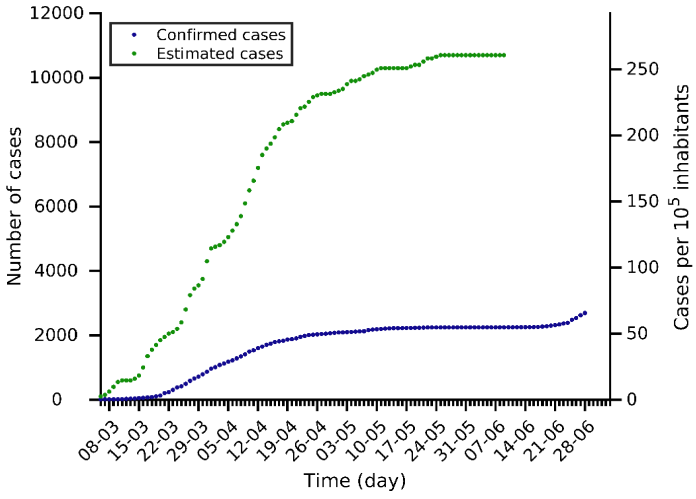


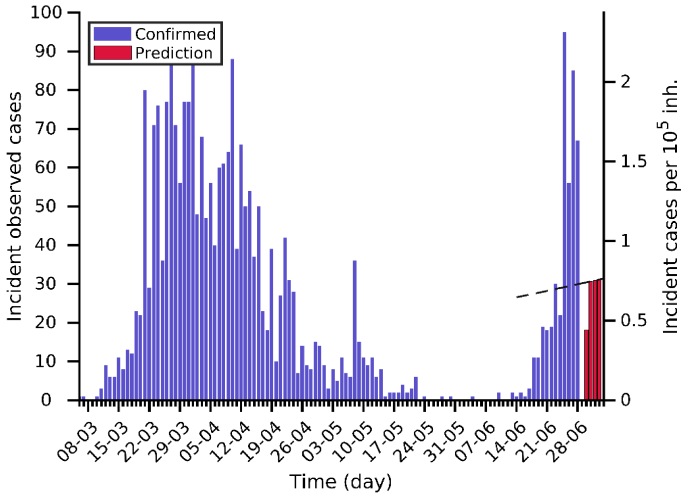


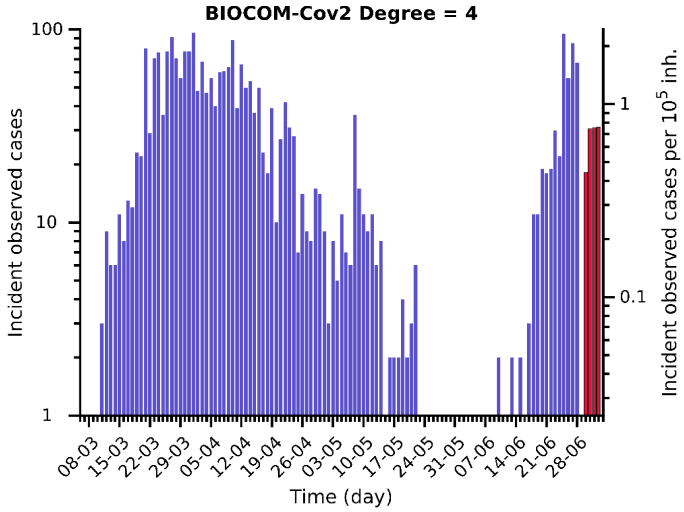


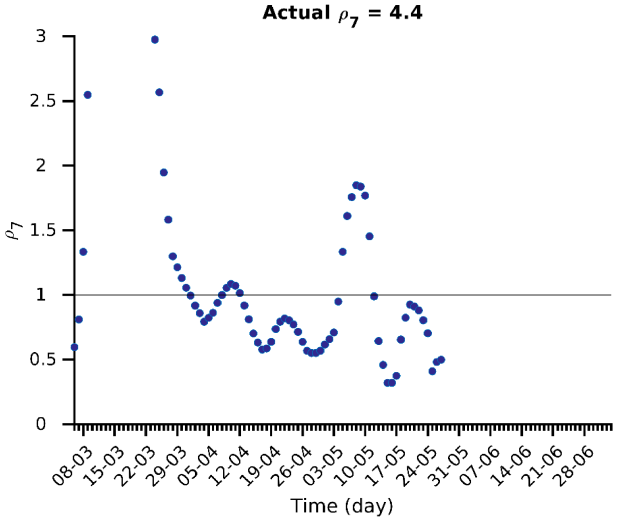
Croatia 28-06-2020. Population: 4.1M. Current cumulative incidence: 66/10^5

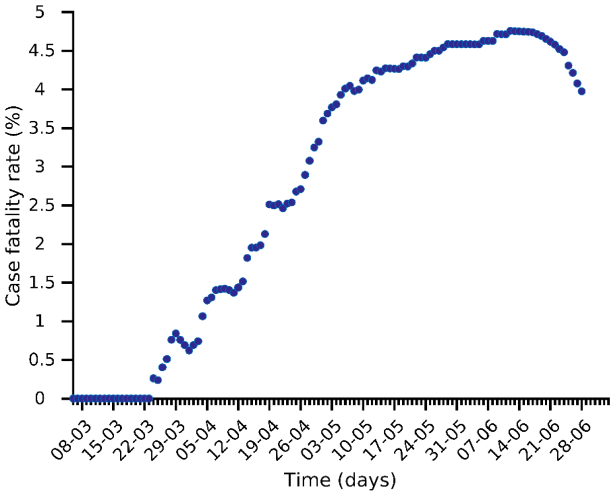


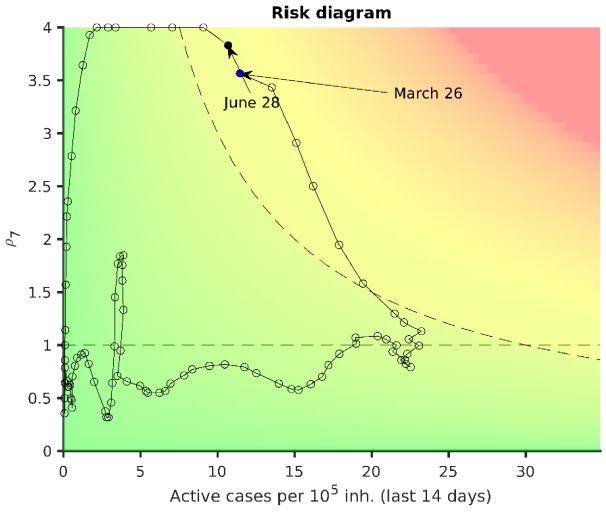


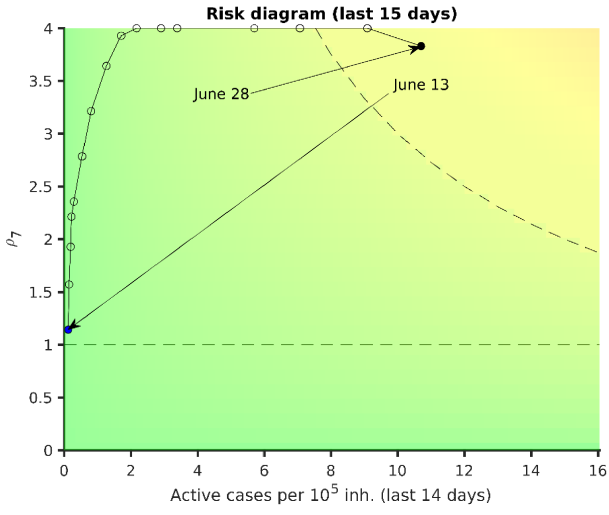




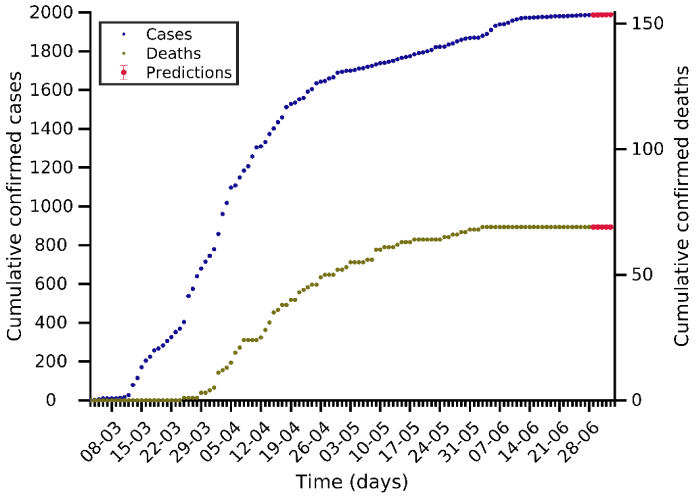


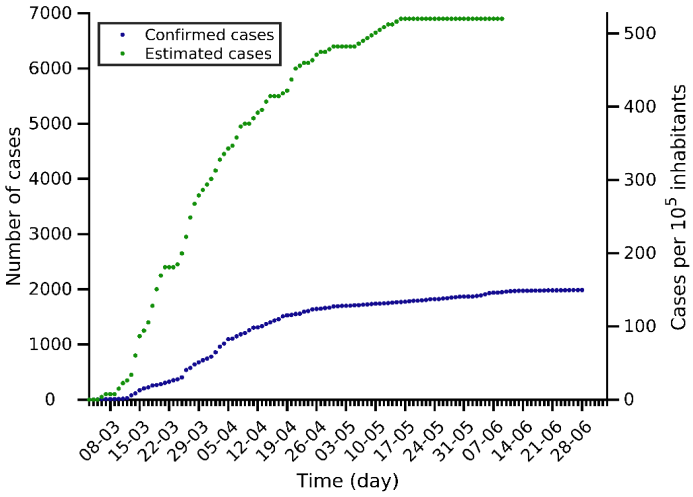


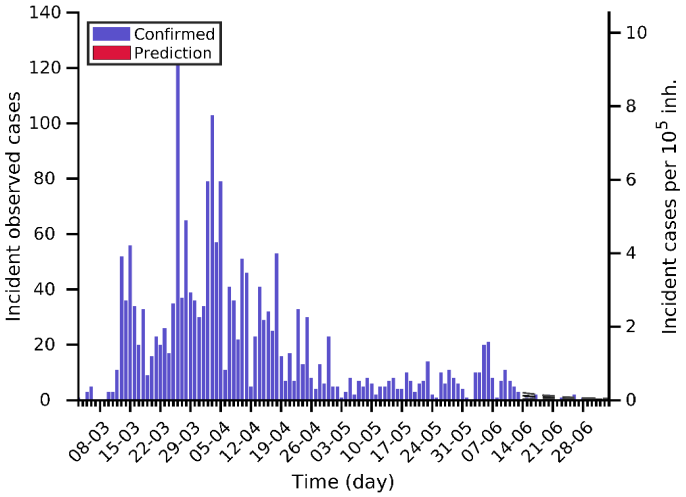


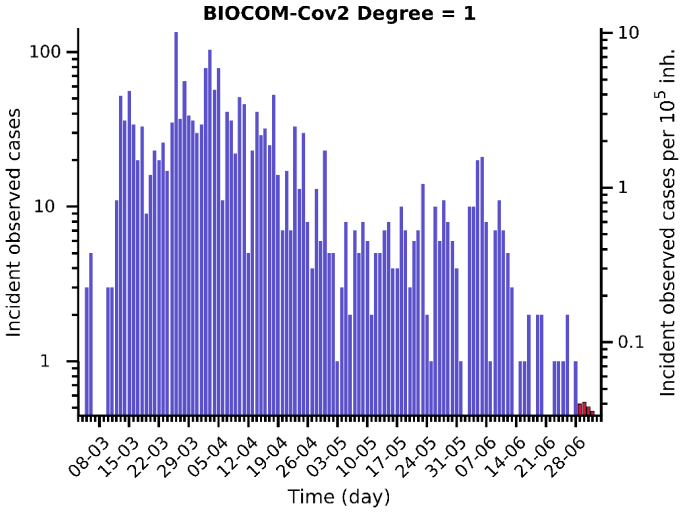


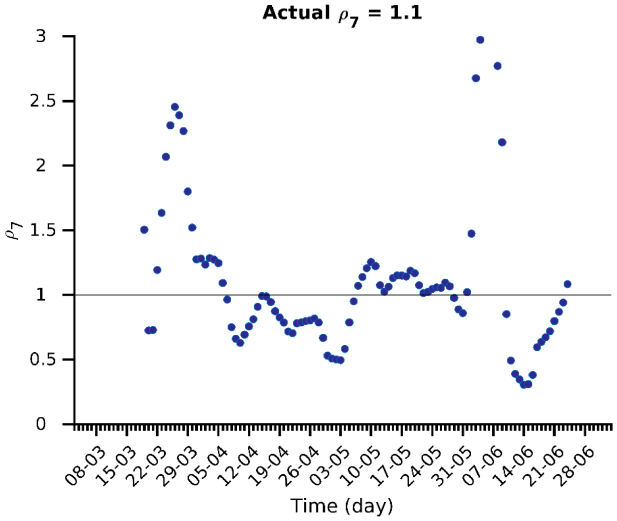
Estonia 28-06-2020. Population: 1.3M. Current cumulative incidence: 150/10^5

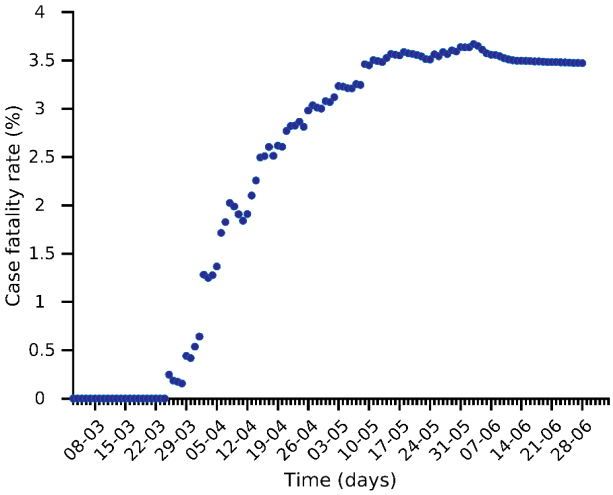


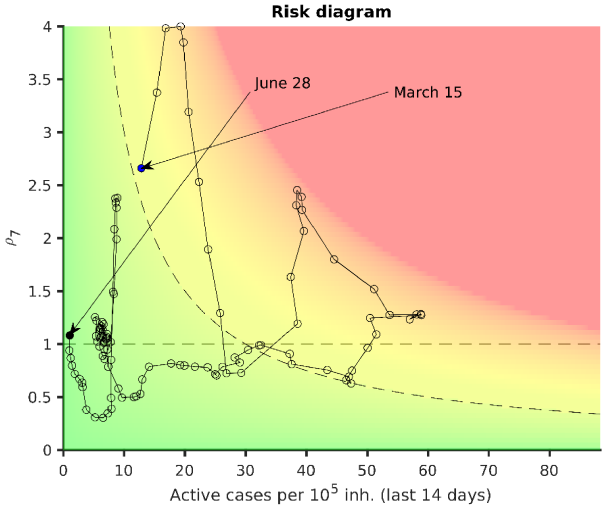


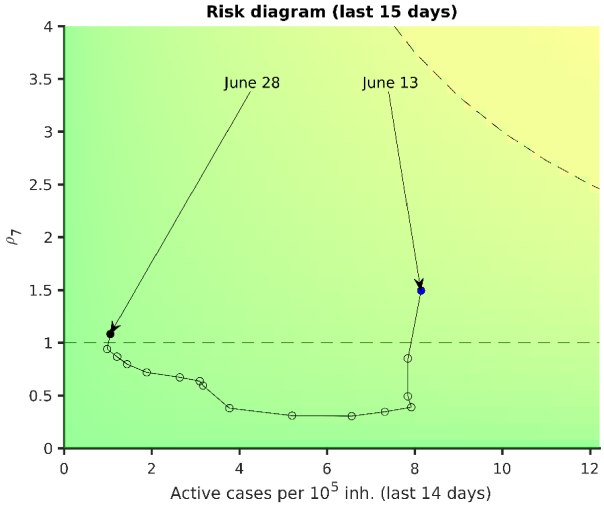




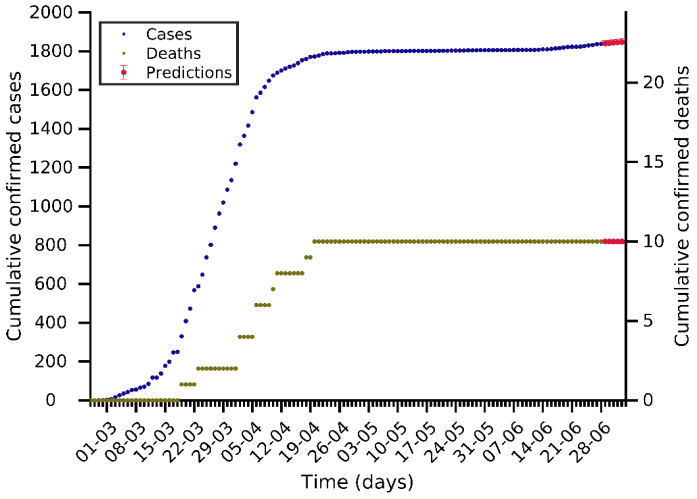


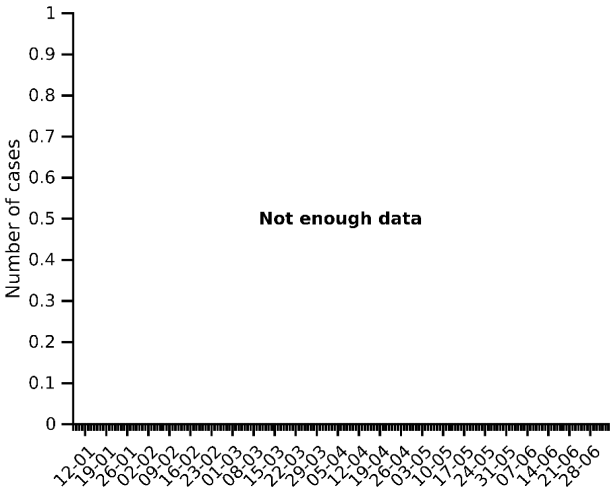


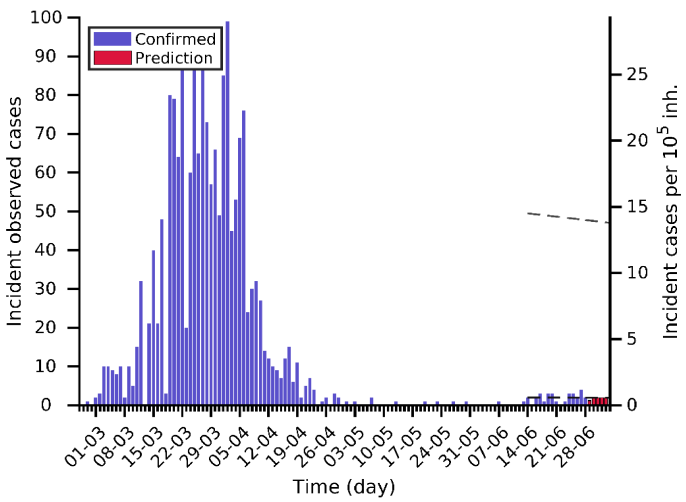


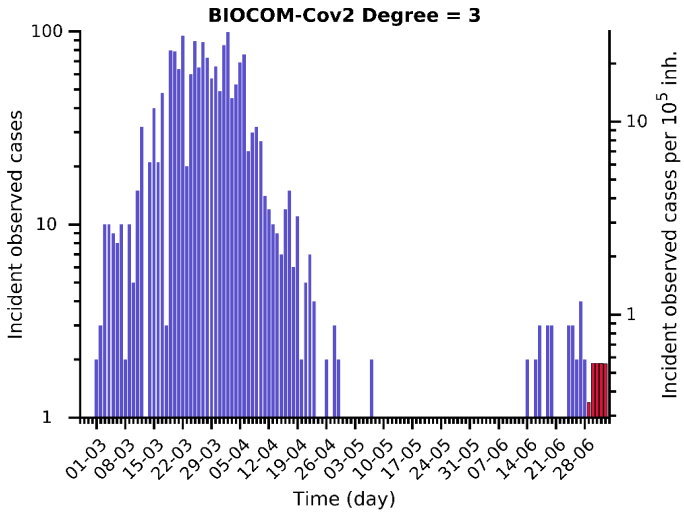


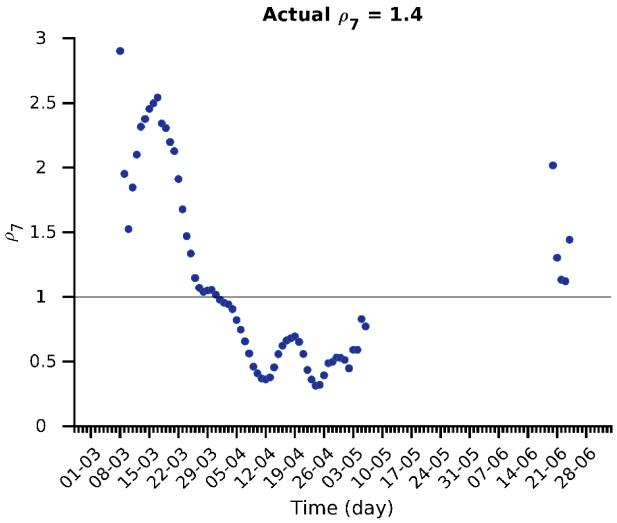
Iceland 28-06-2020. Population: 0.3M. Current cumulative incidence: 539/10⁵

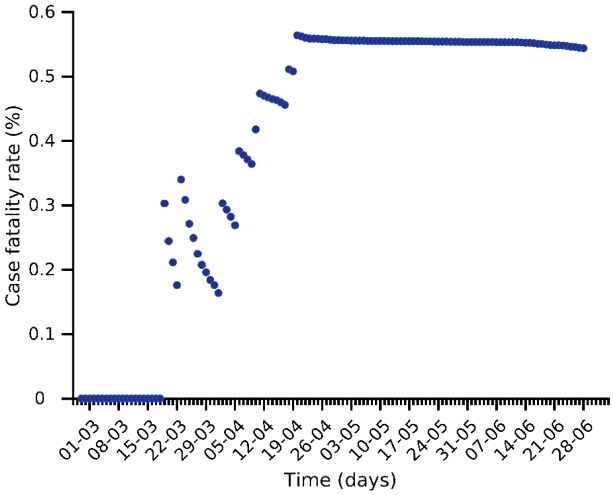


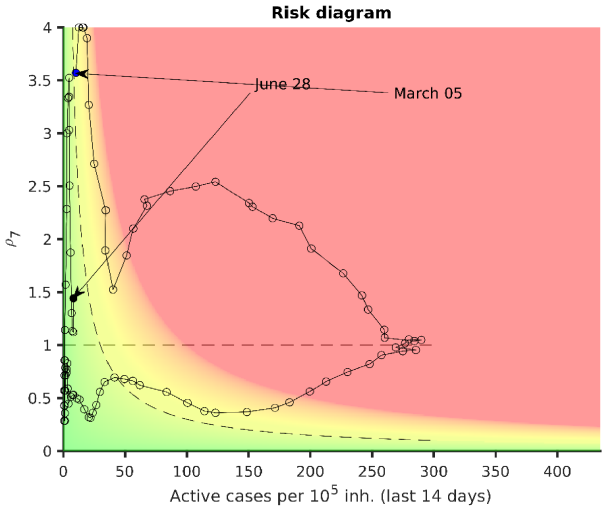


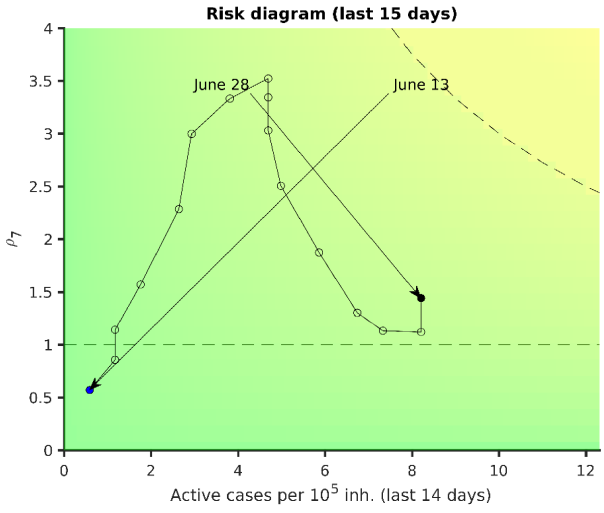




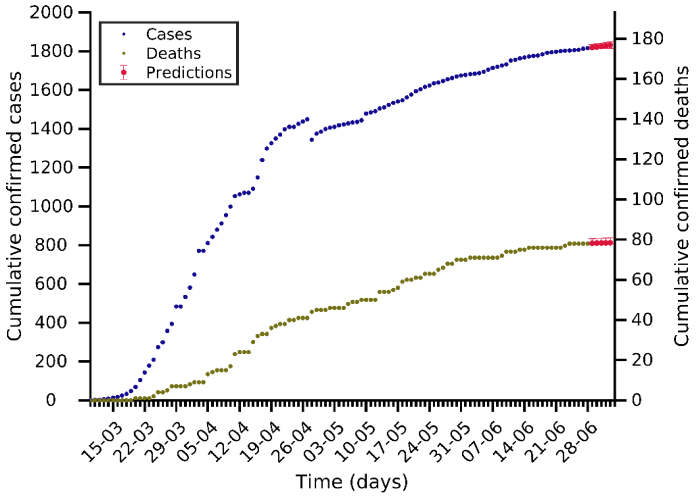


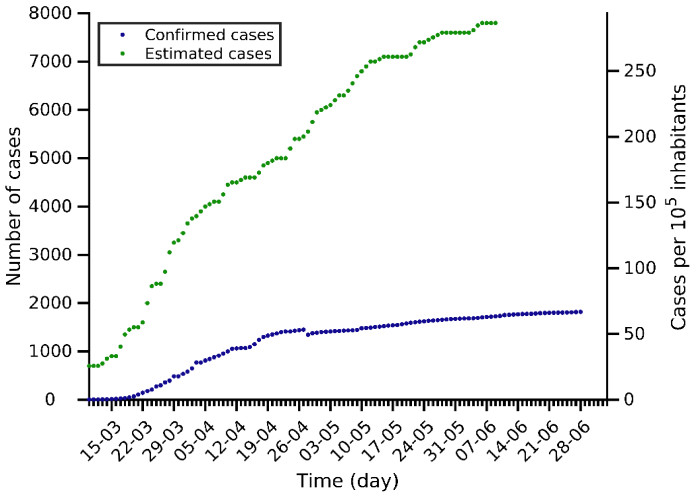


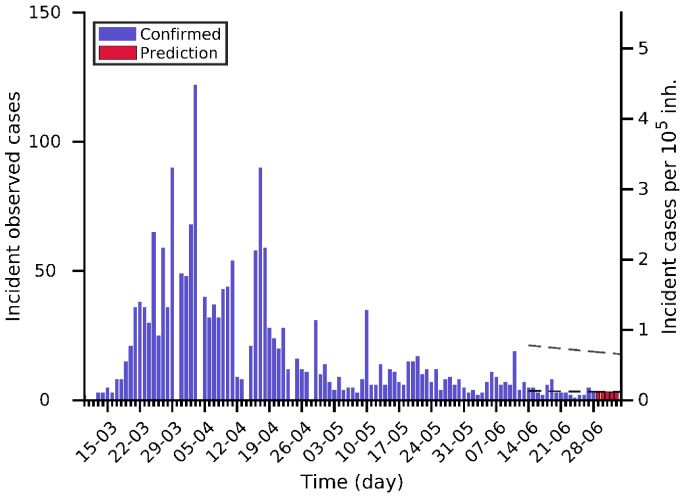


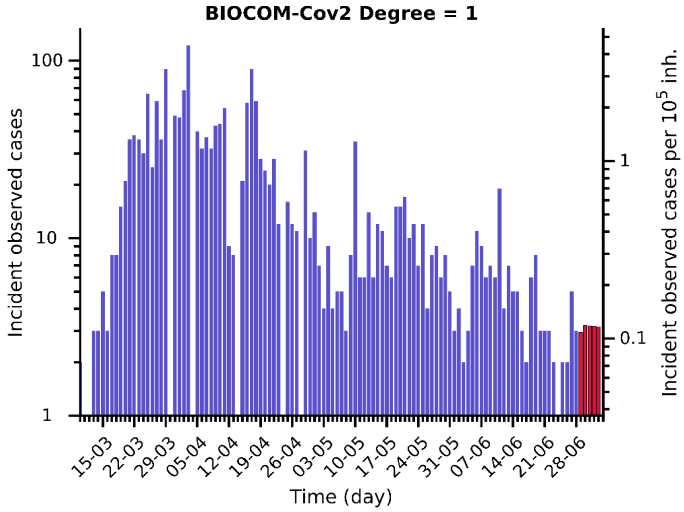


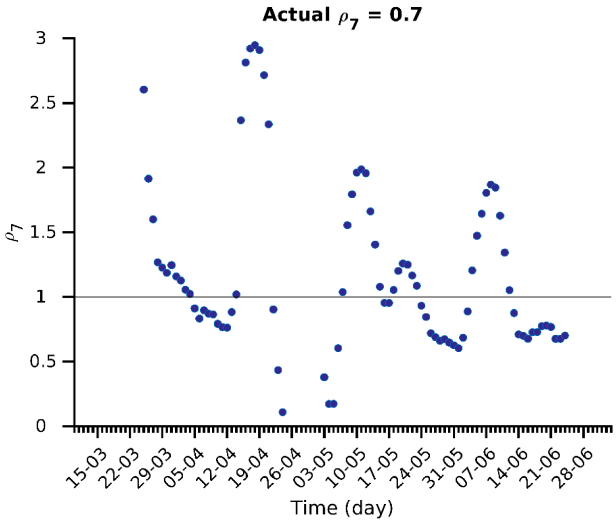
Lithuania 28-06-2020. Population: 2.7M. Current cumulative incidence: 67/10^5

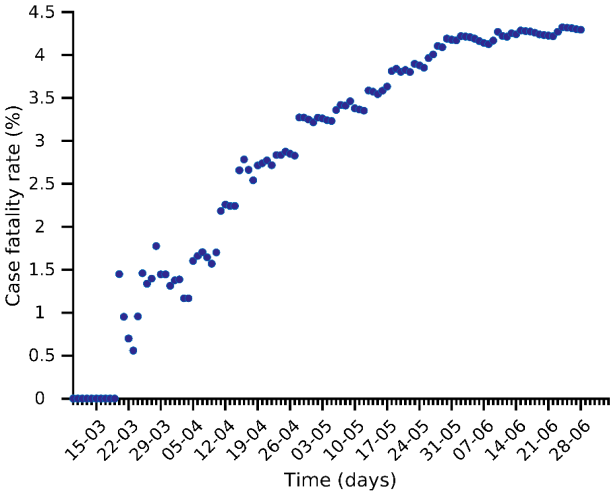


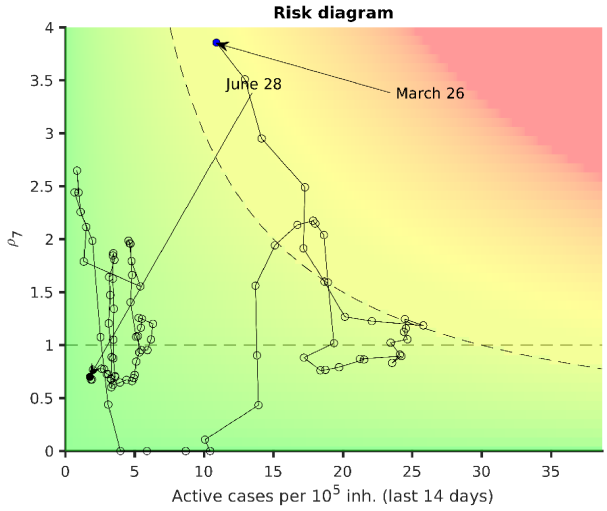


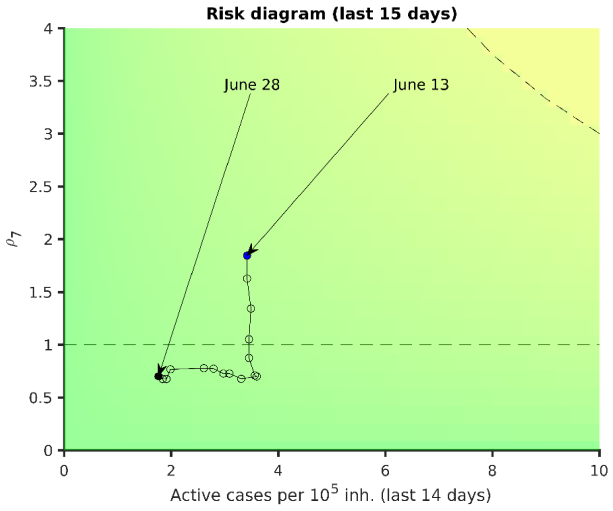




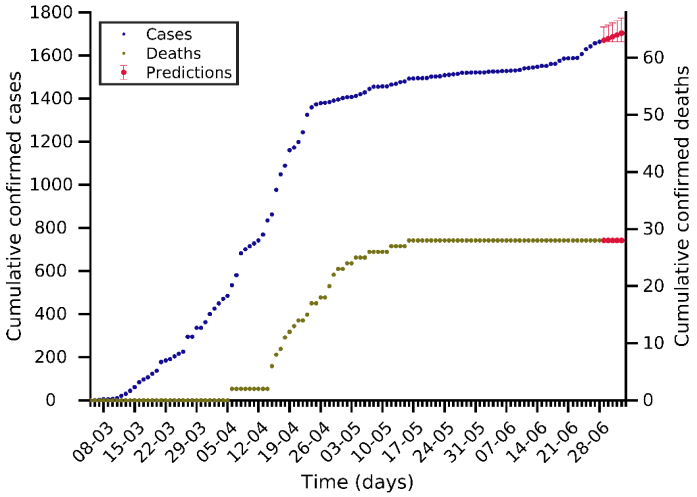


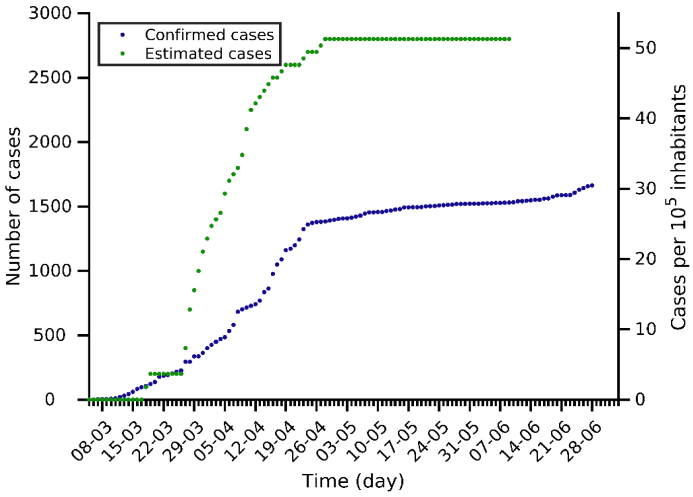


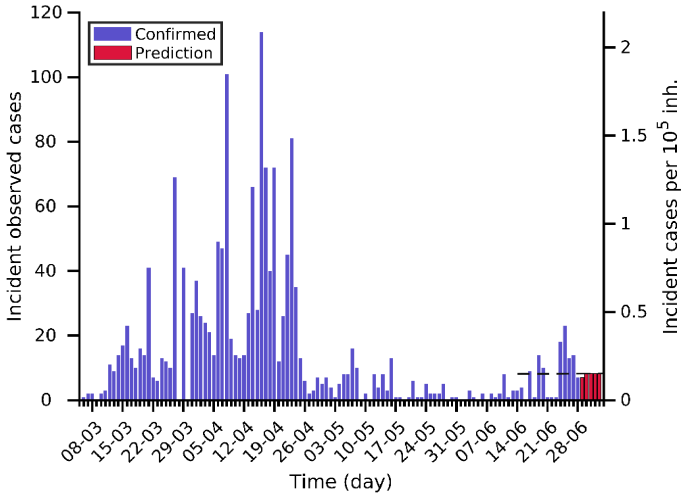


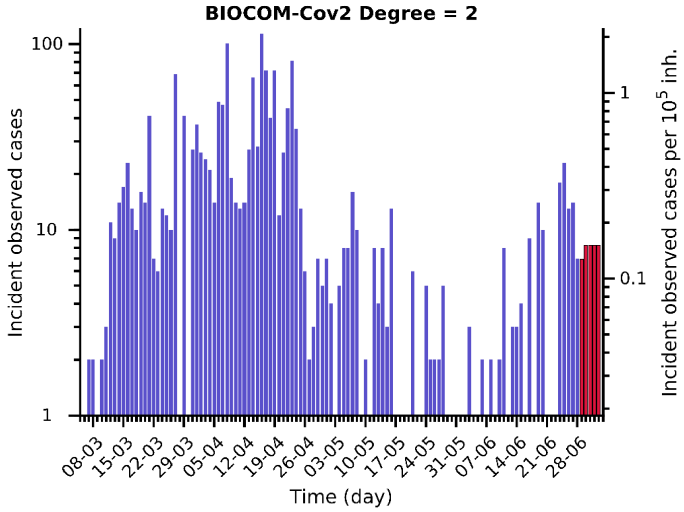


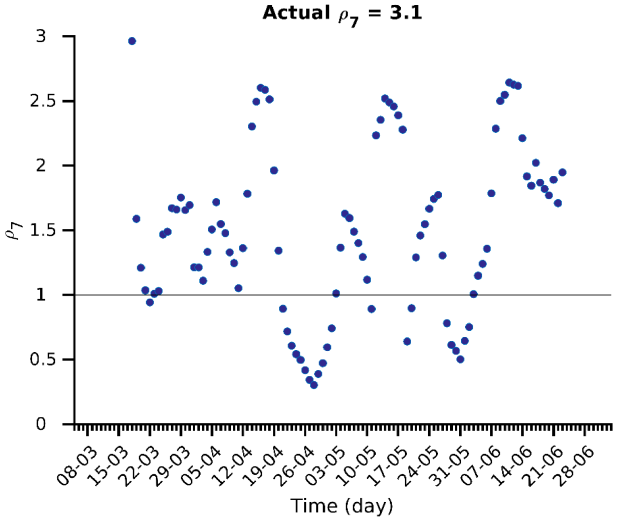
Slovakia 28-06-2020. Population: 5.5M. Current cumulative incidence: $30/10^5$

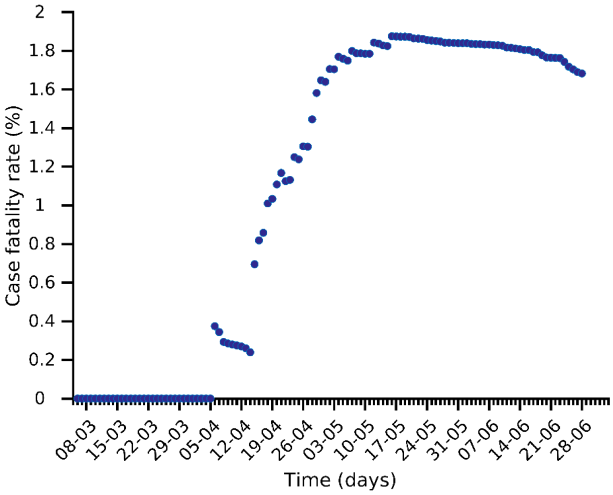


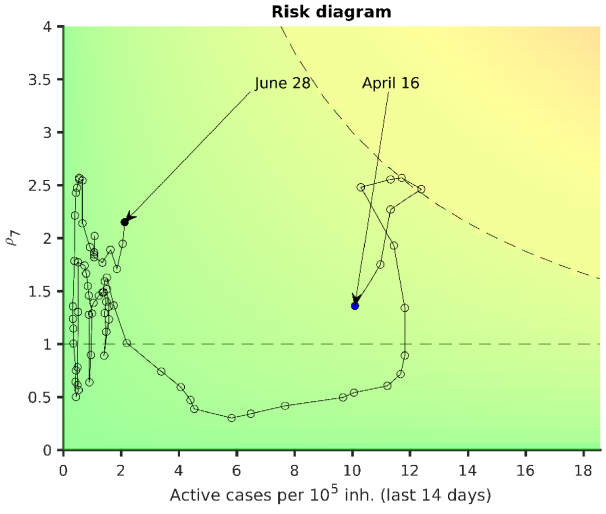


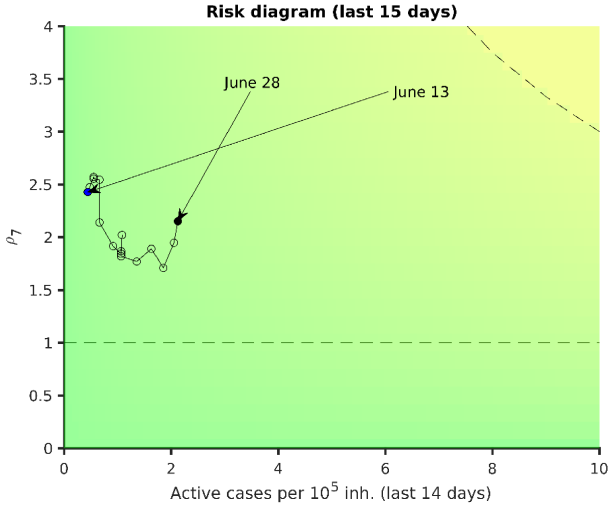




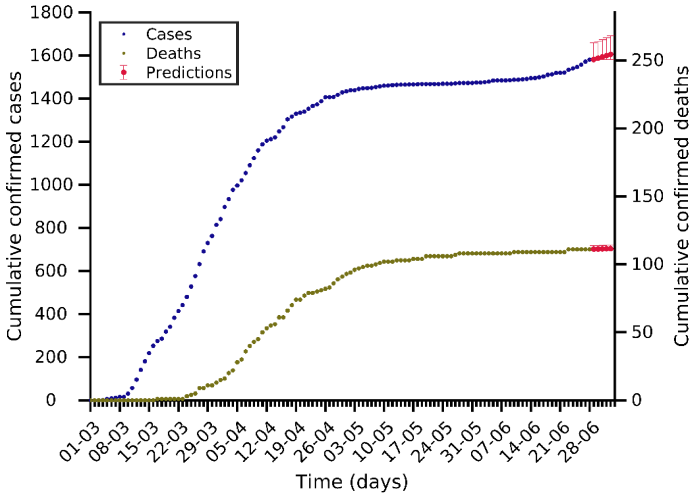


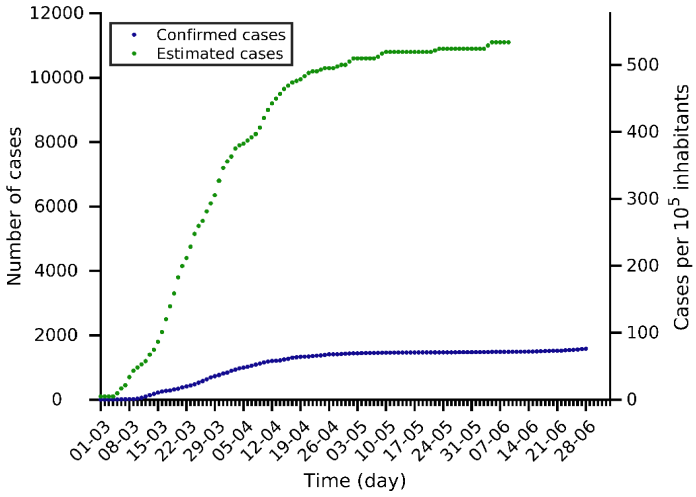


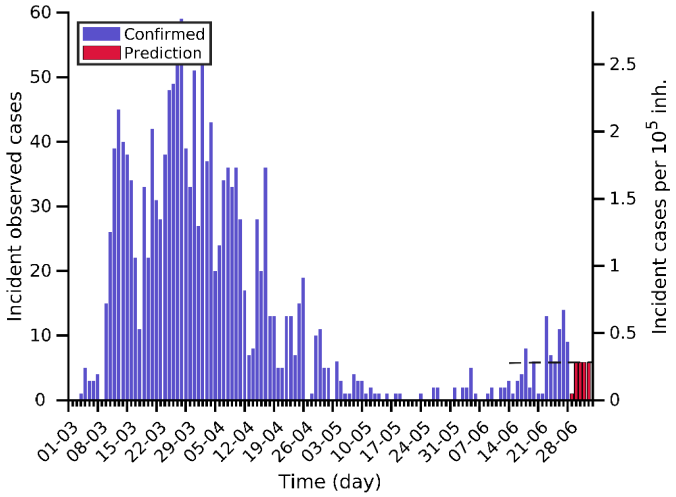


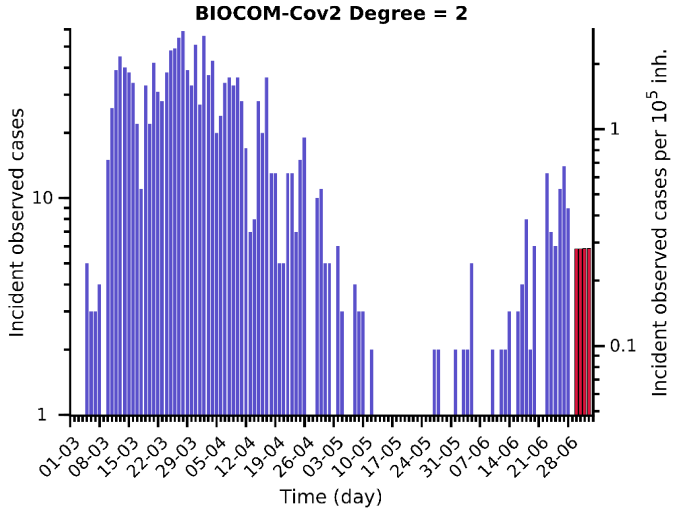


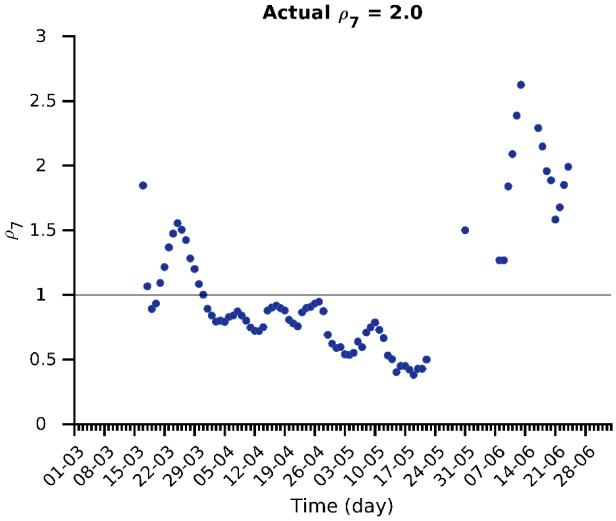
Slovenia 28-06-2020. Population: 2.1M. Current cumulative incidence: 76/10⁵

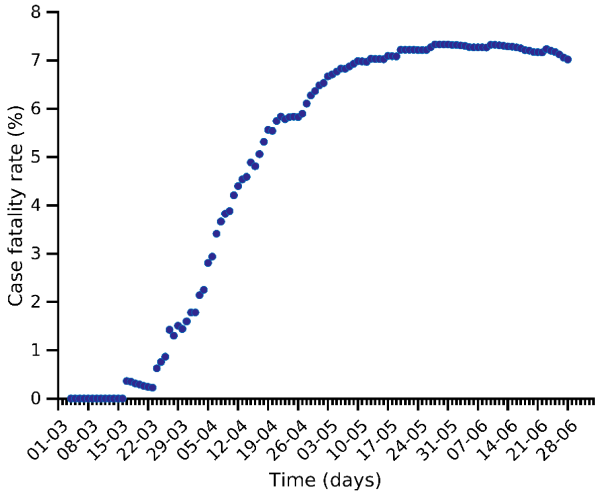


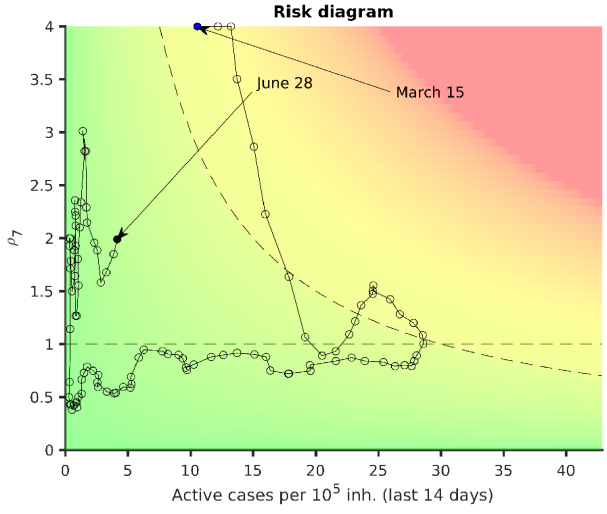


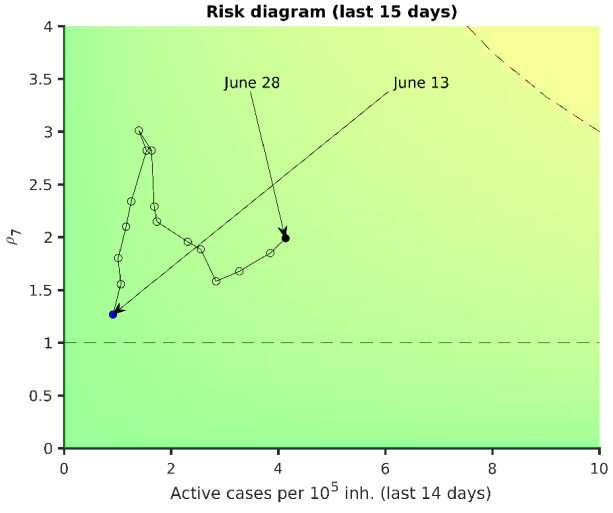




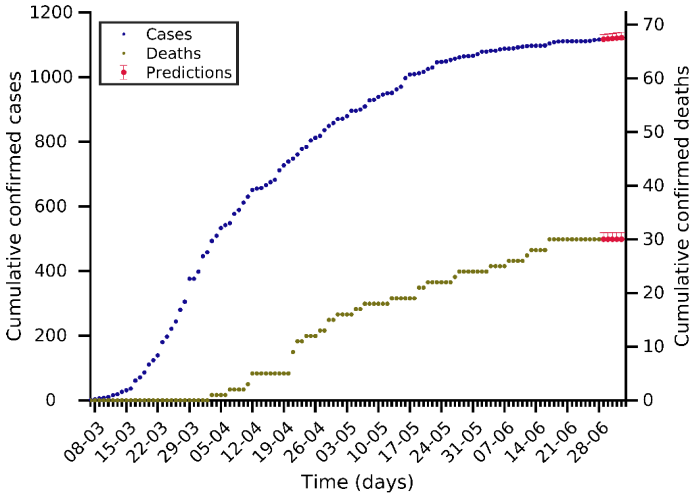


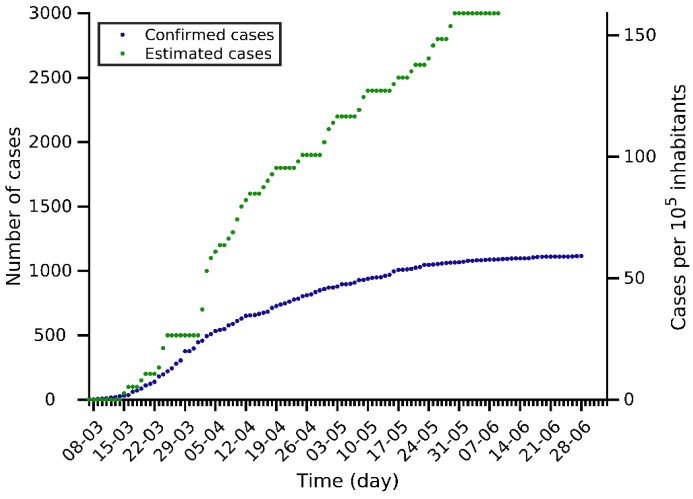


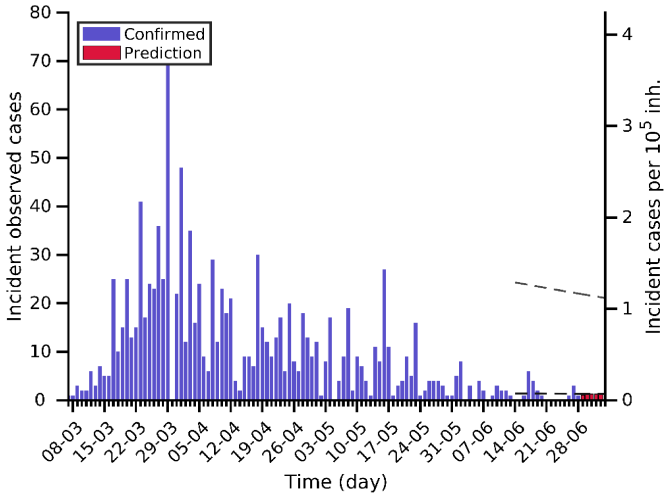


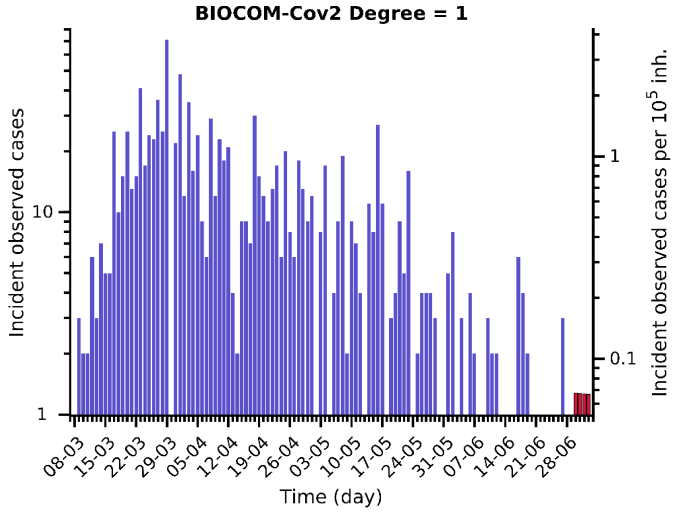


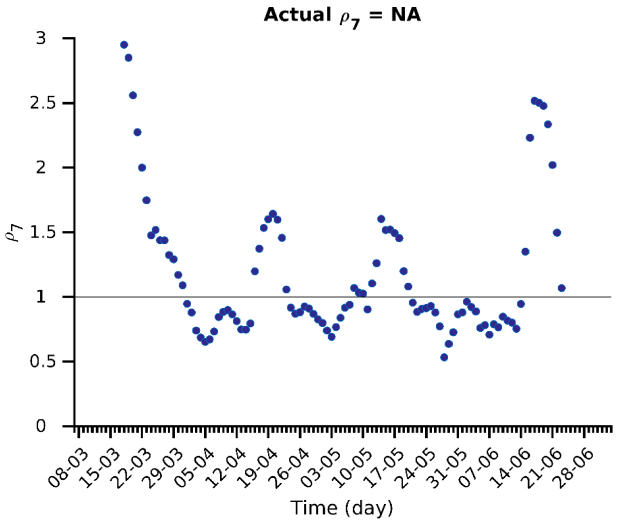
Latvia 28-06-2020. Population: 1.9M. Current cumulative incidence: 59/10^5

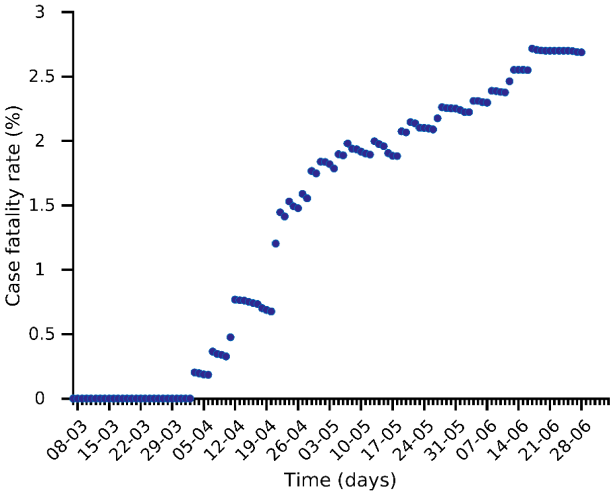


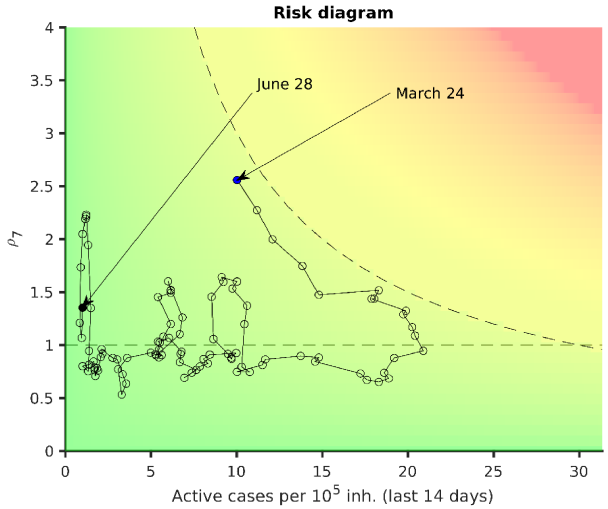


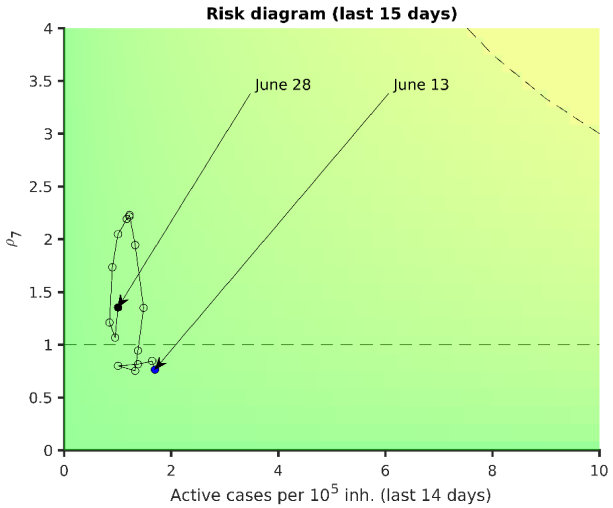




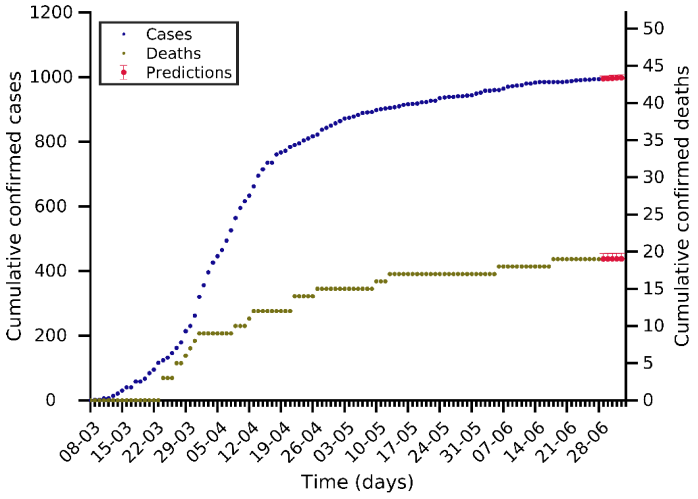


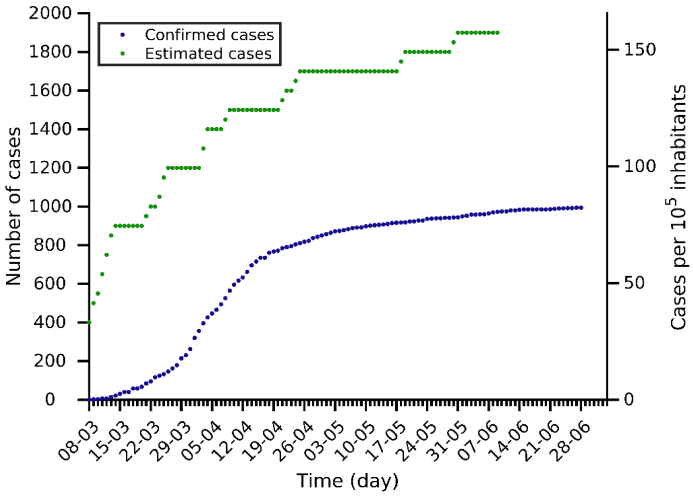


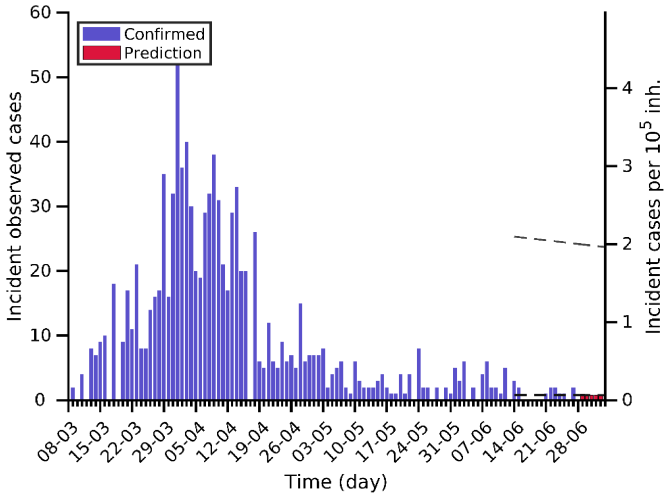


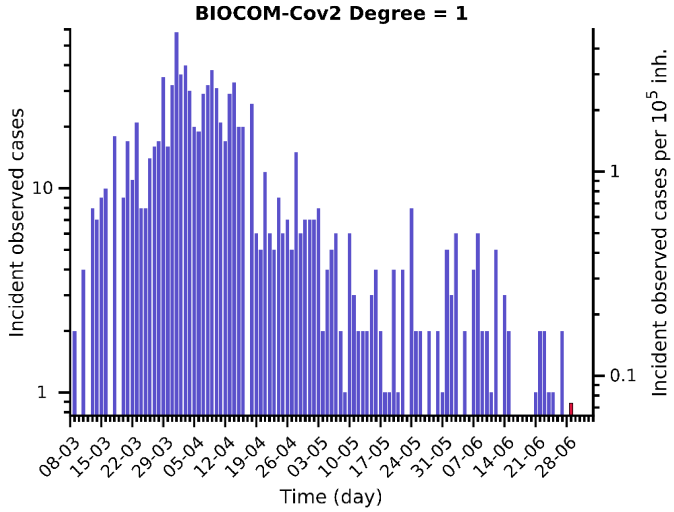


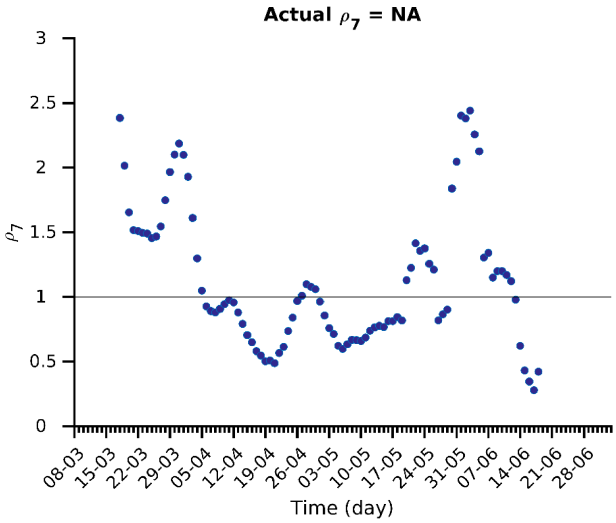
Cyprus 28-06-2020. Population: 1.2M. Current cumulative incidence: 82/10^5

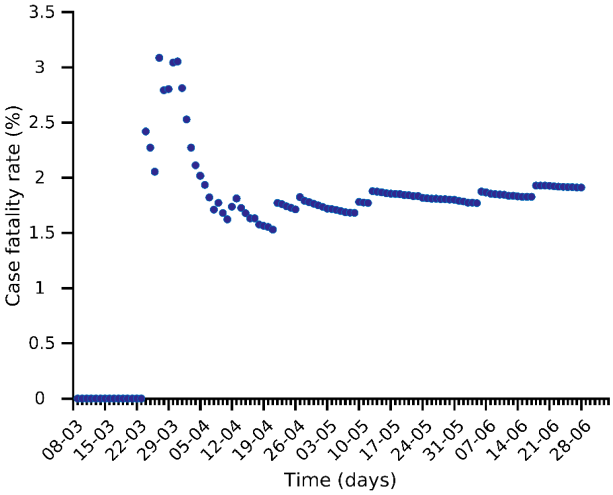


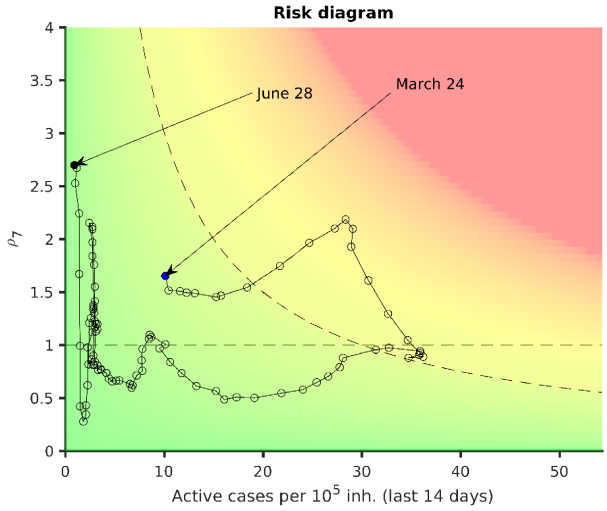


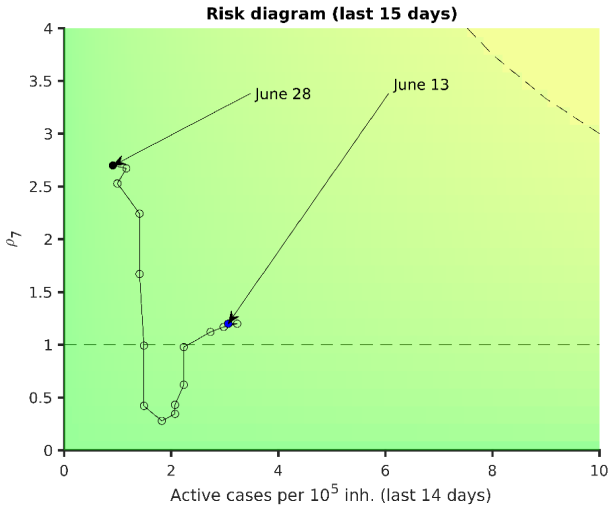




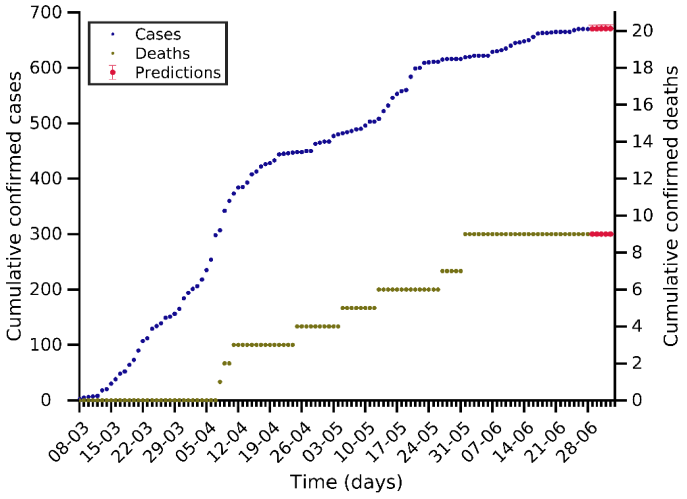


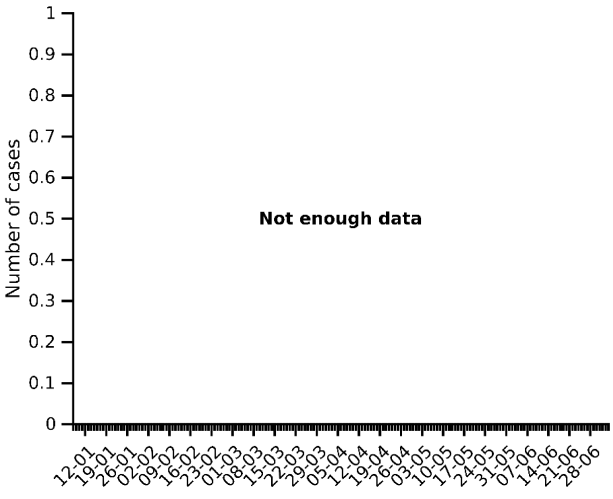


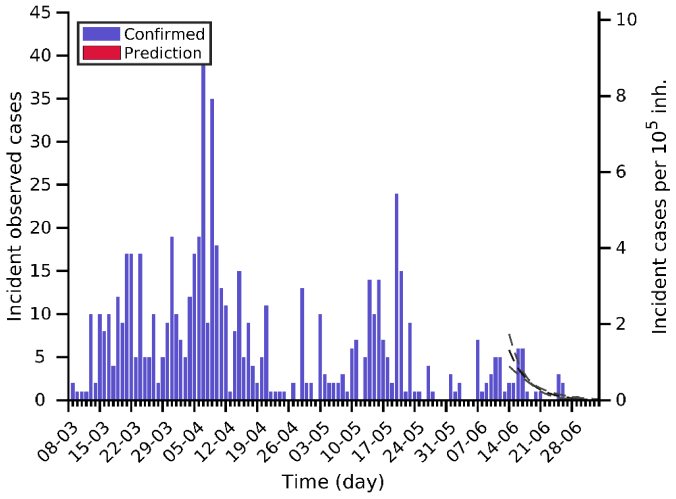


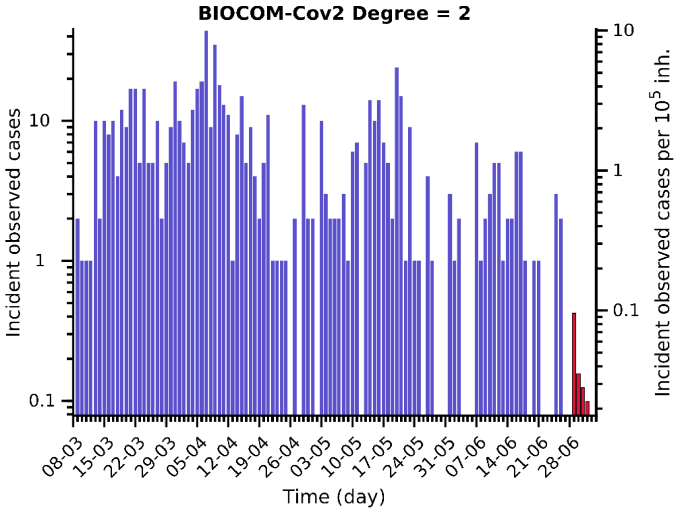


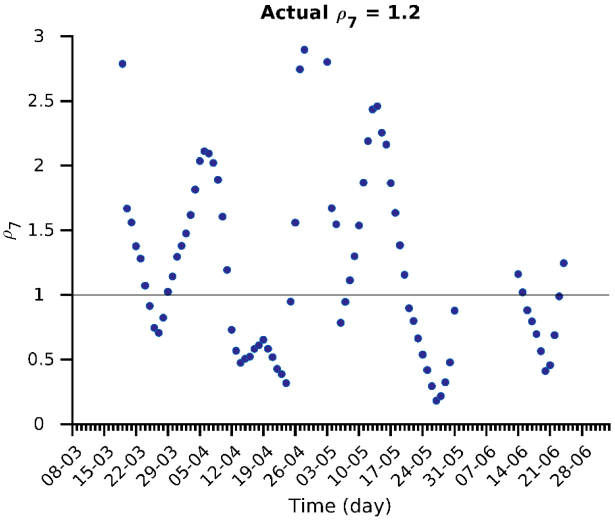
Malta 28-06-2020. Population: 0.4M. Current cumulative incidence: 152/10⁵

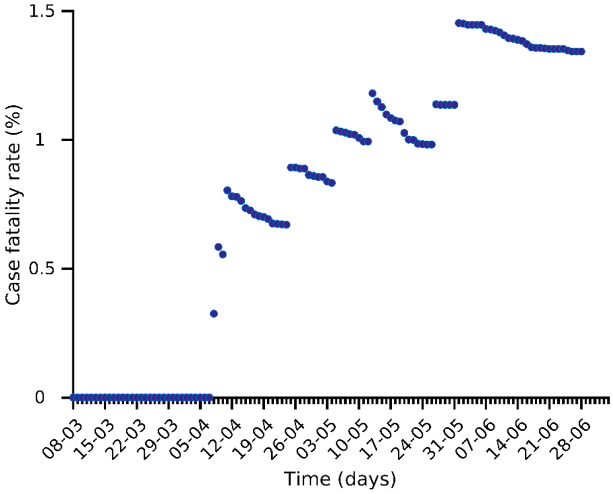


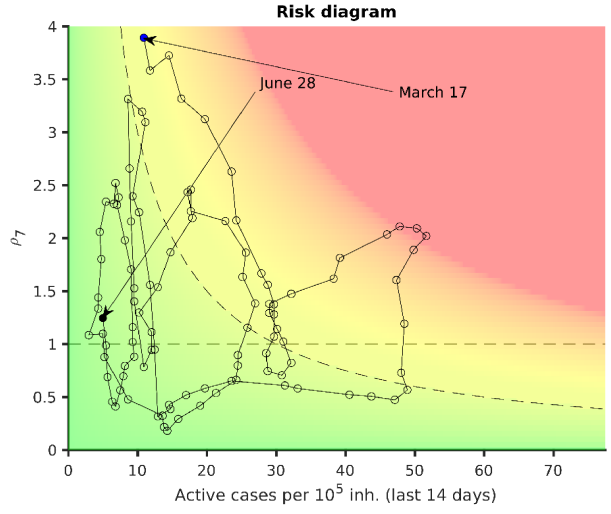


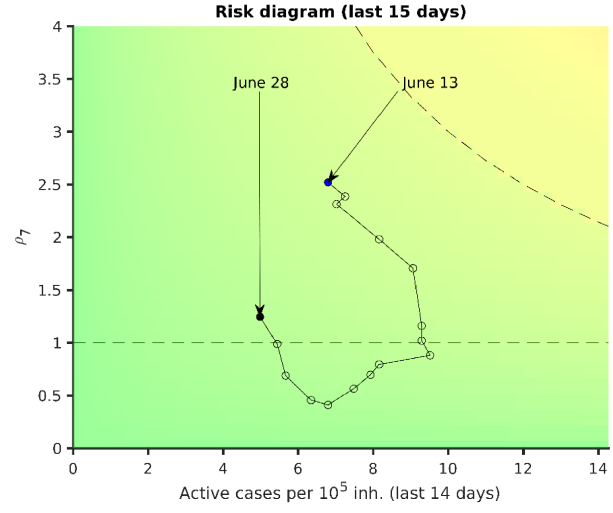








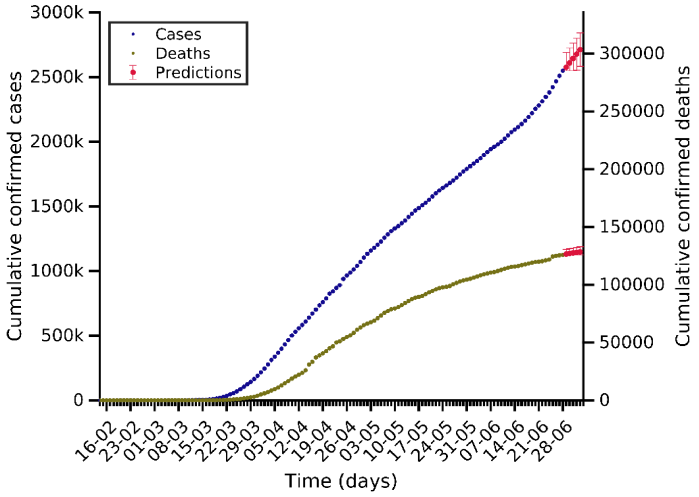


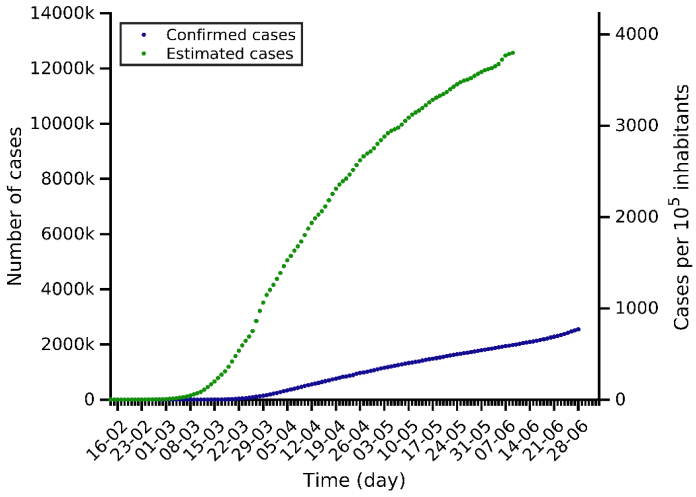


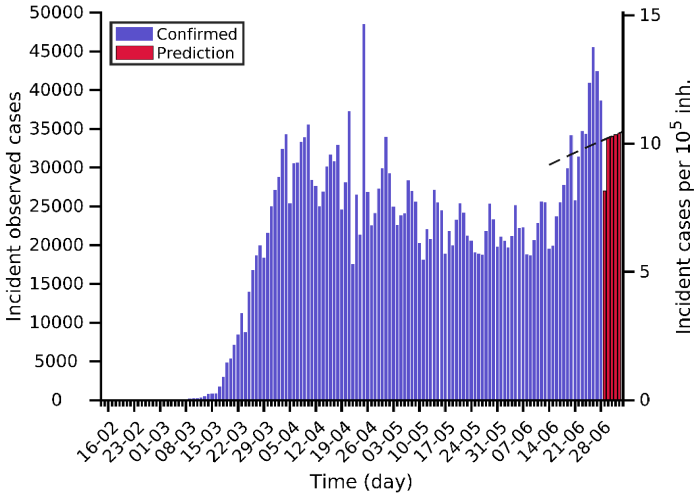
(2) Analysis and prediction of COVID-19 for other countries

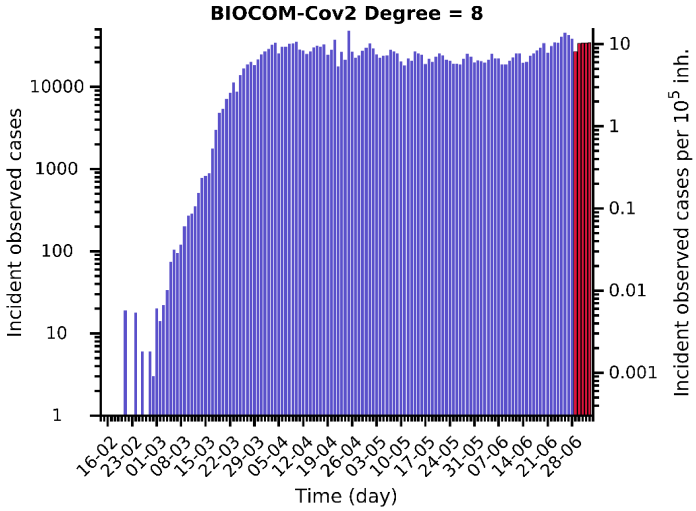
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

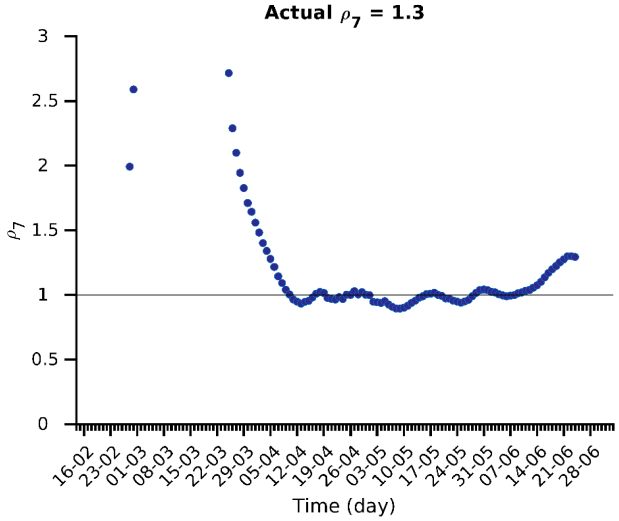
USA 28-06-2020. Population: 331.0M. Current cumulative incidence: 770/10⁵

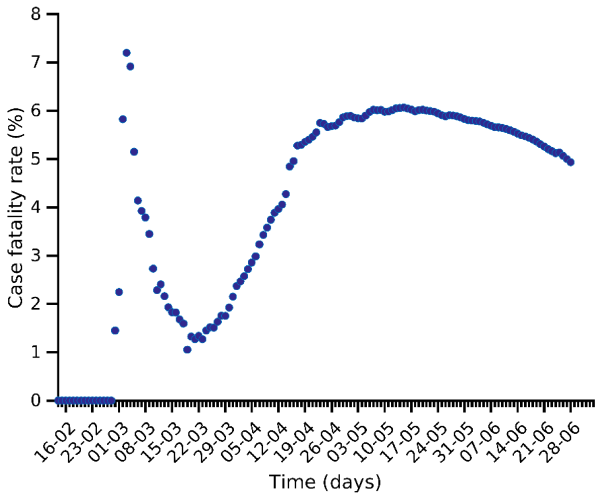


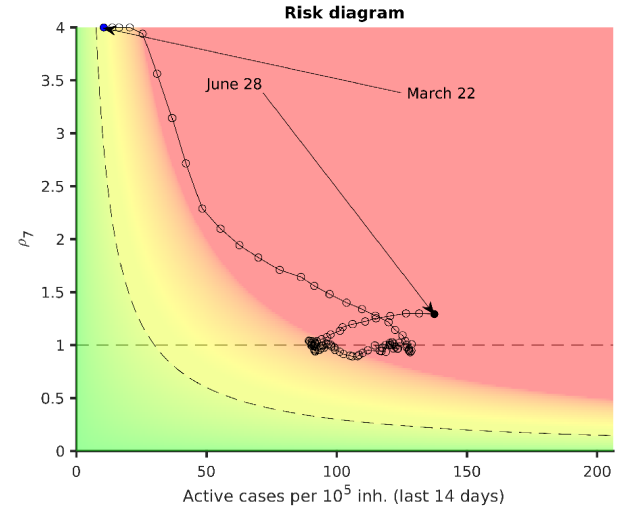


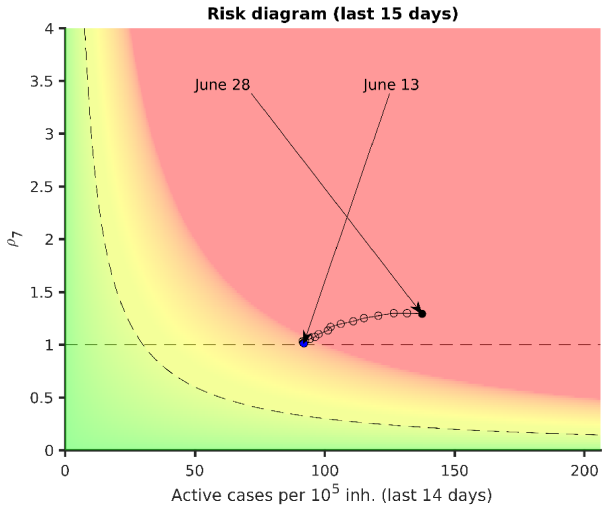




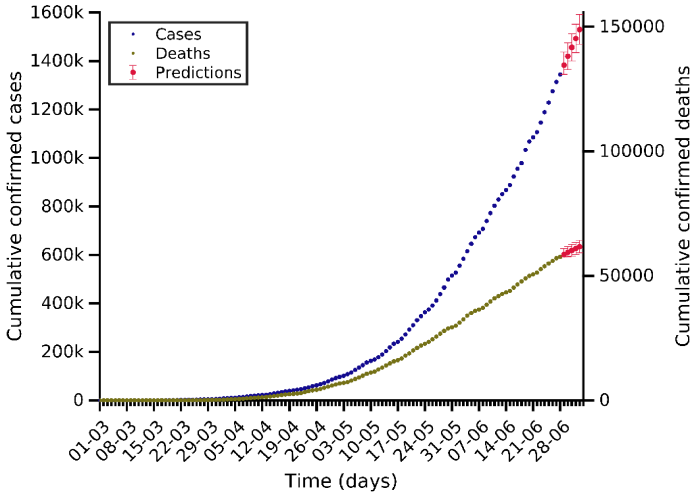


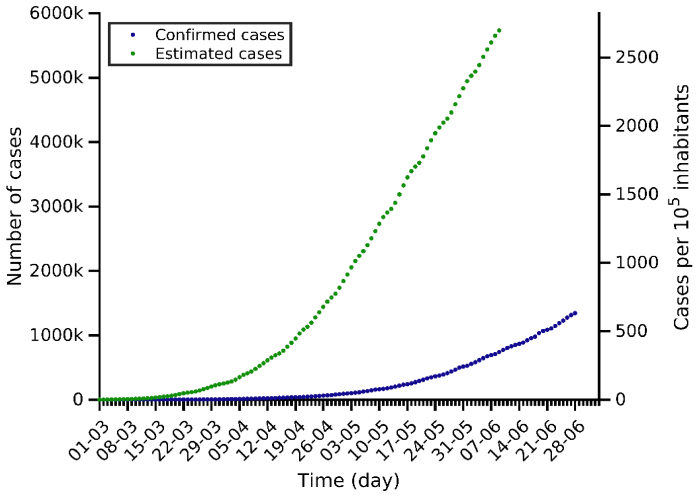


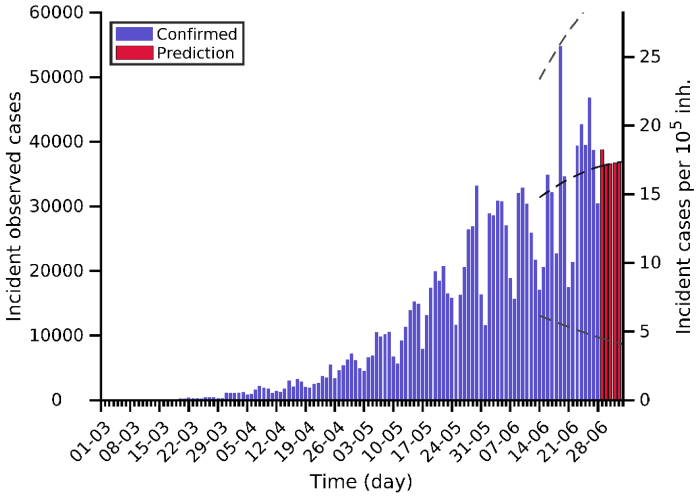


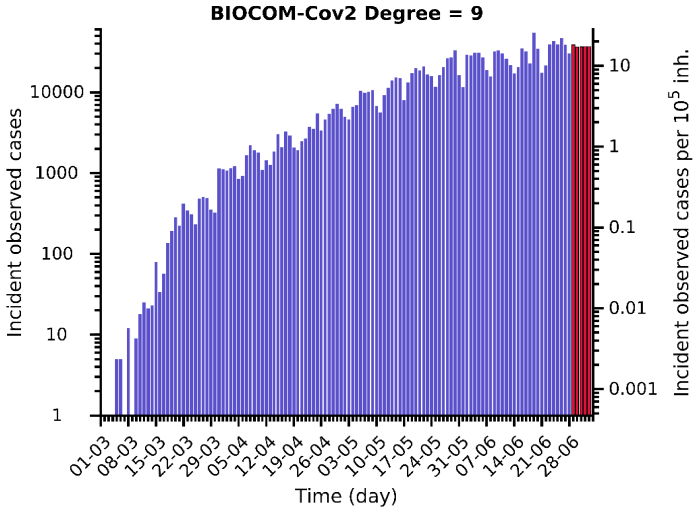


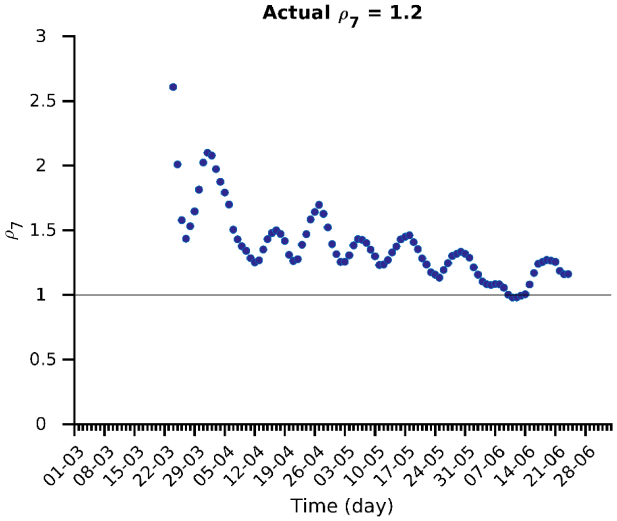
Brazil 28-06-2020. Population: 212.6M. Current cumulative incidence: 632/10^5

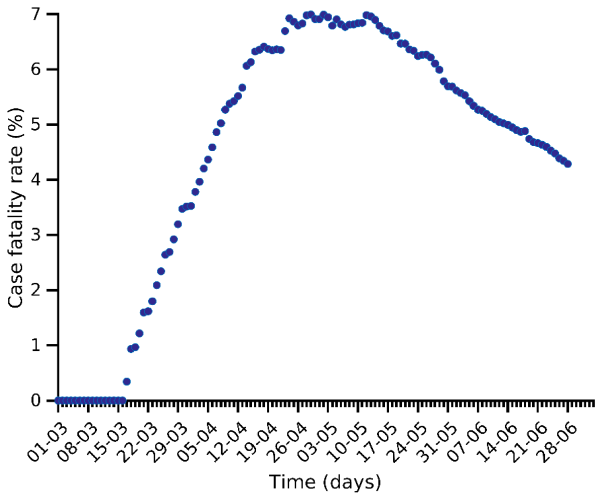


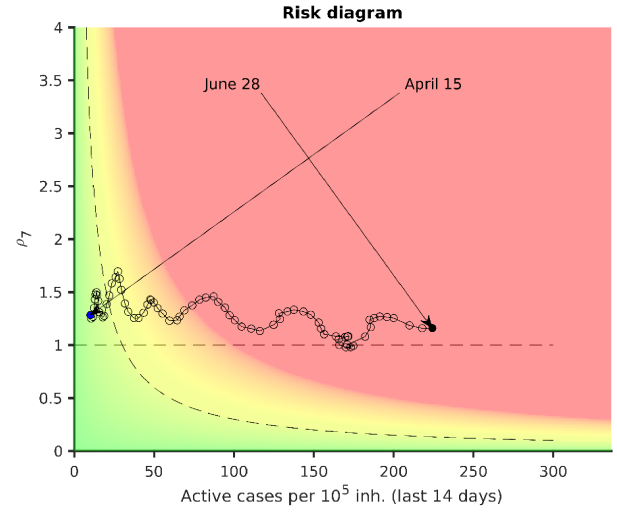


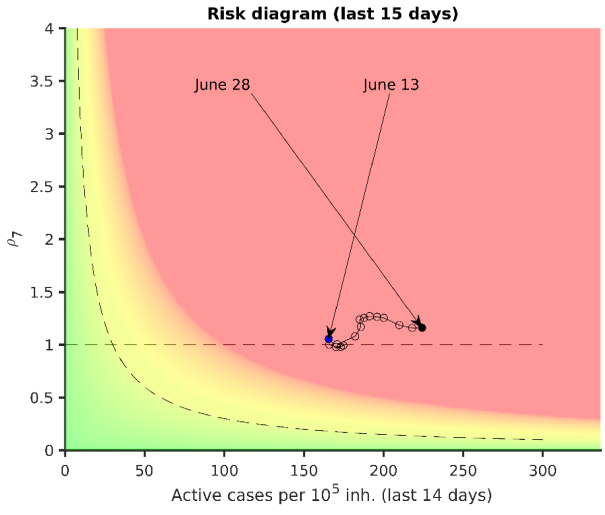




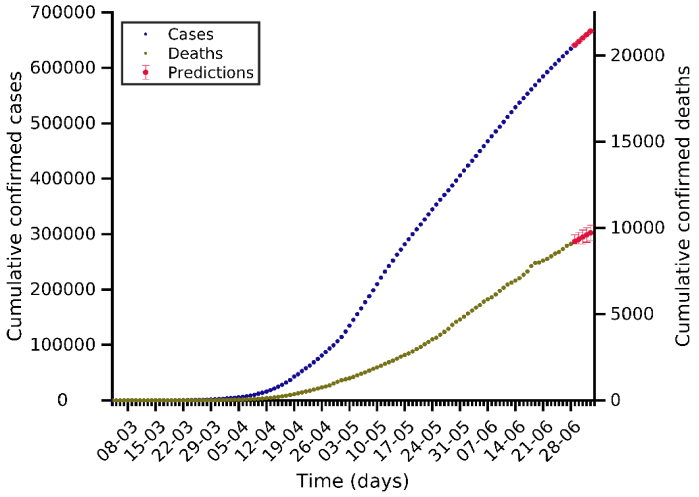


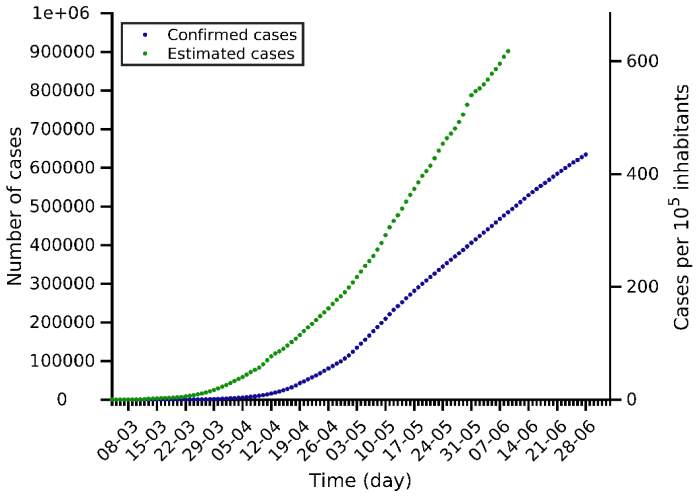


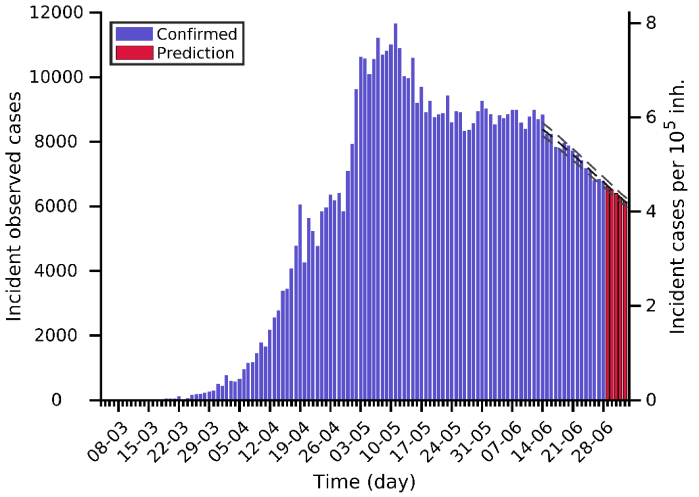


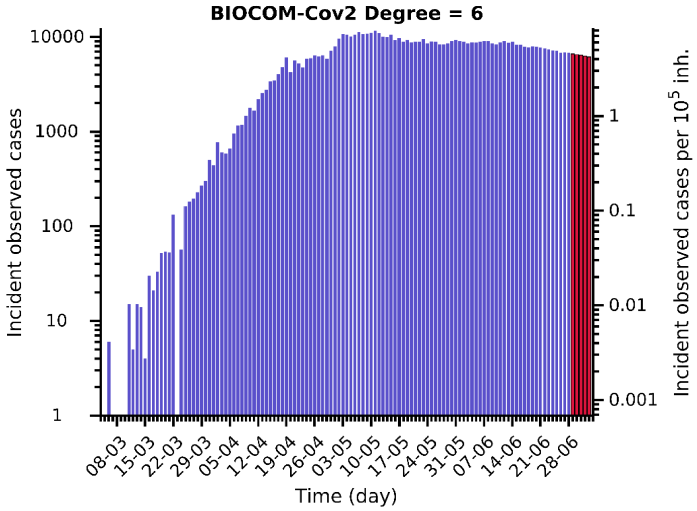


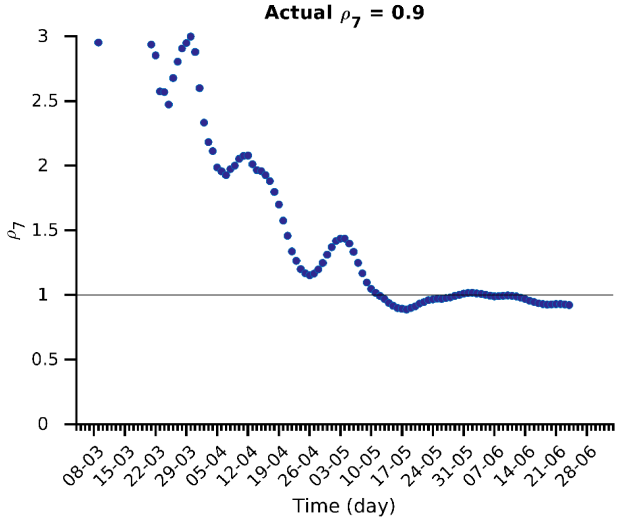
Russia 28-06-2020. Population: 145.9M. Current cumulative incidence: 435/10⁵

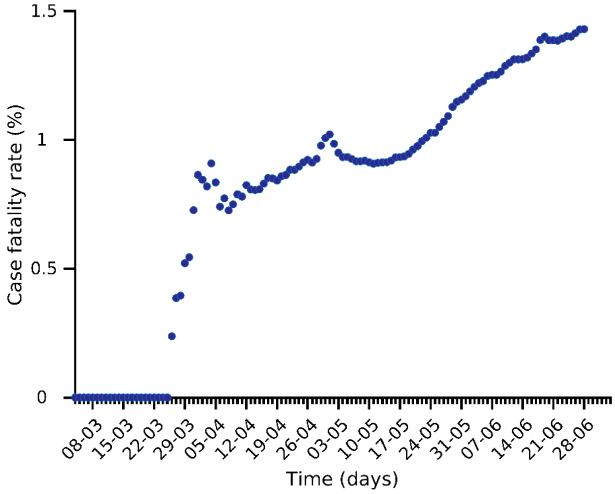


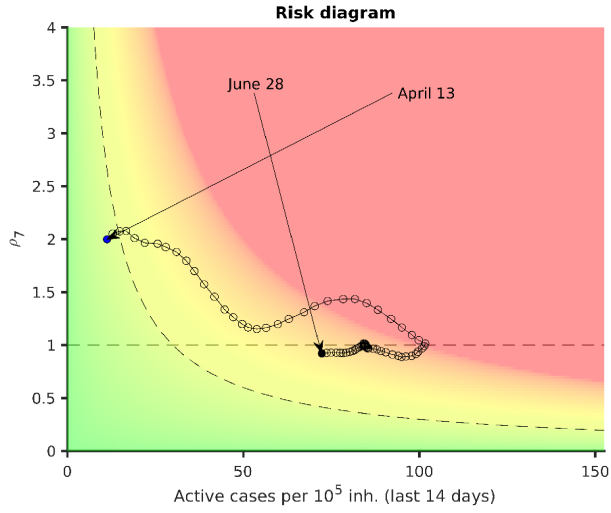


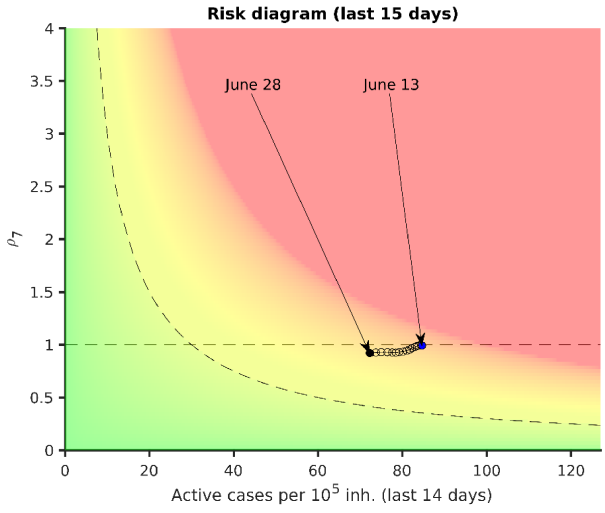




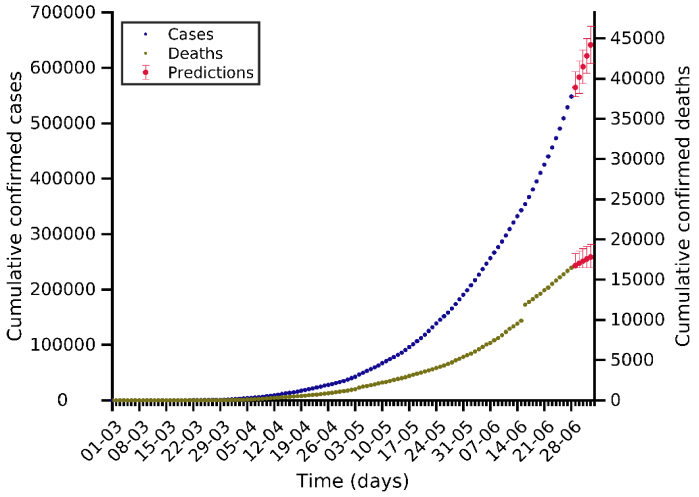


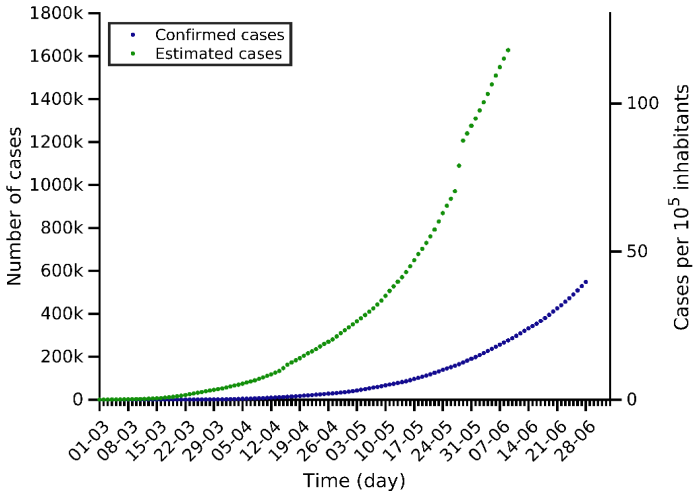


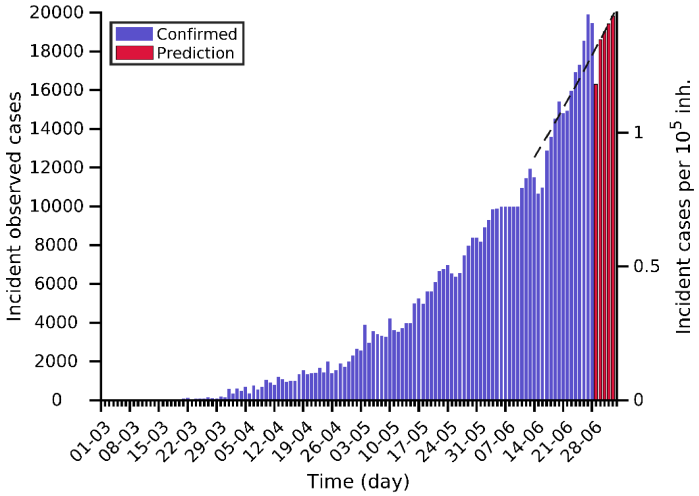


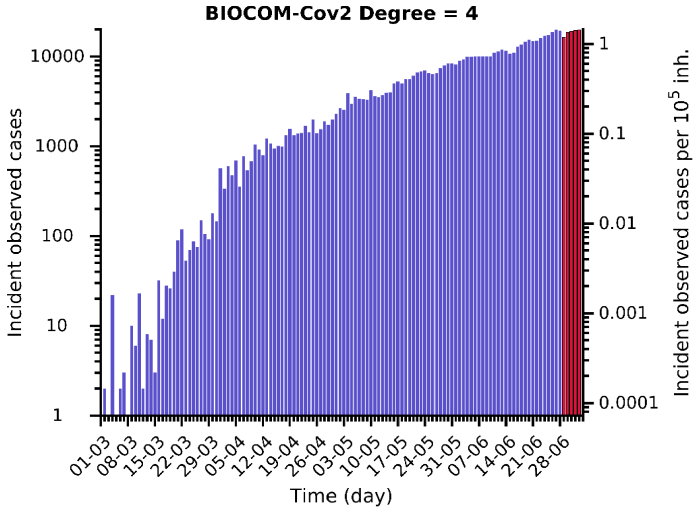


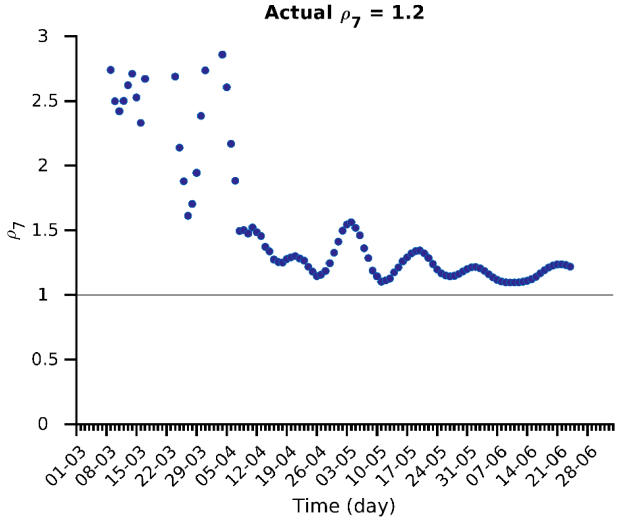
India 28-06-2020. Population: 1380.0M. Current cumulative incidence: 40/10^5

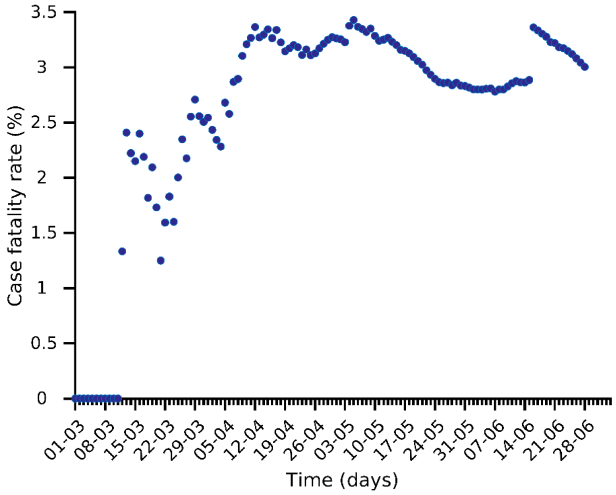


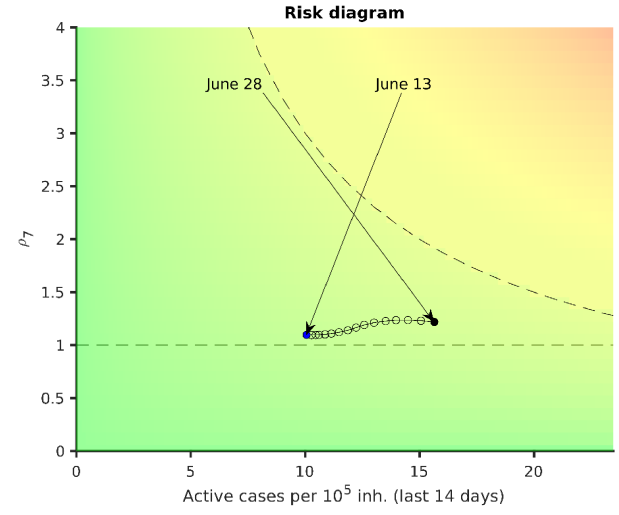


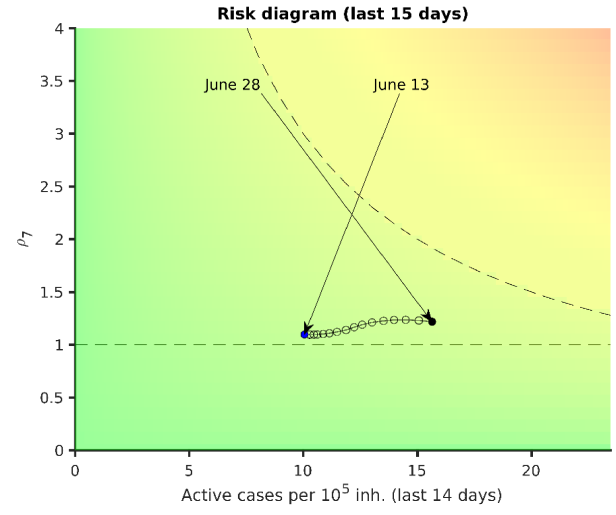




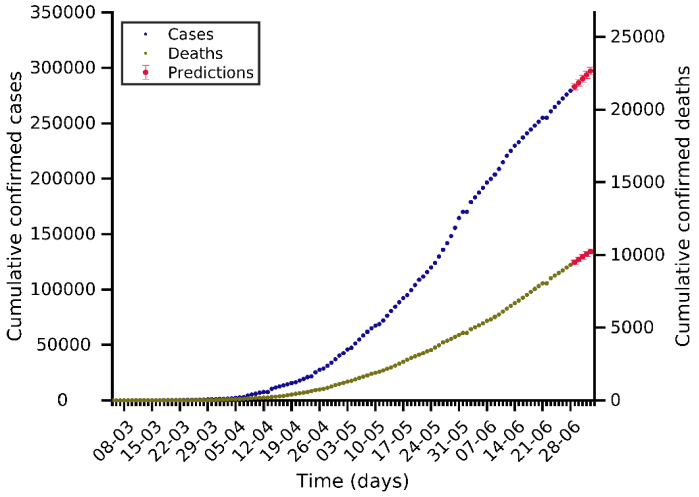


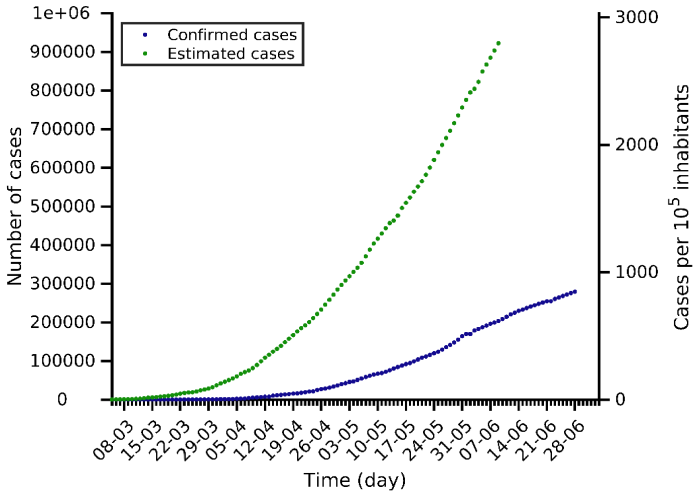


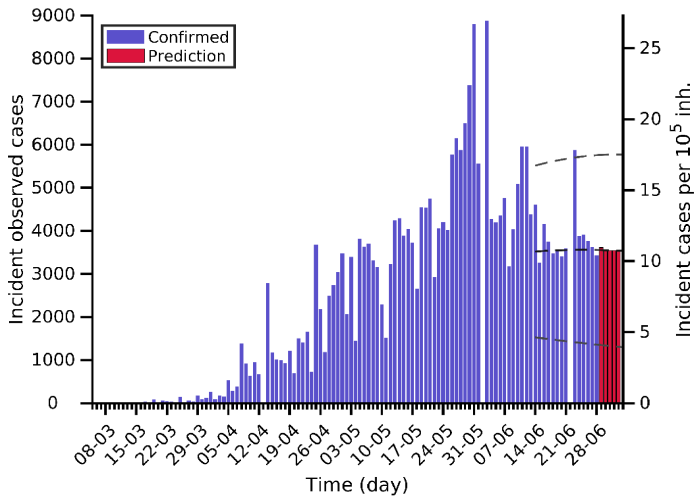


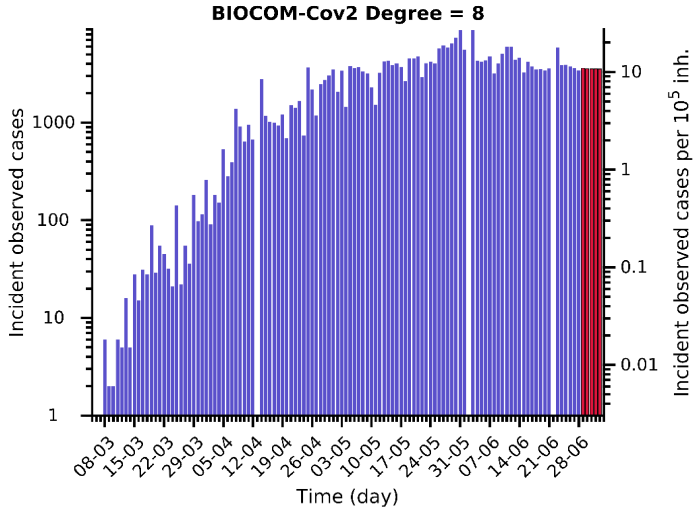


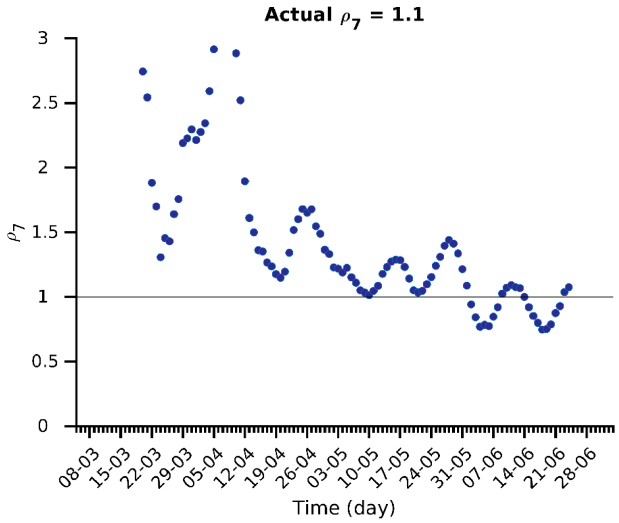
Peru 28-06-2020. Population: 33.0M. Current cumulative incidence: 847/10⁵

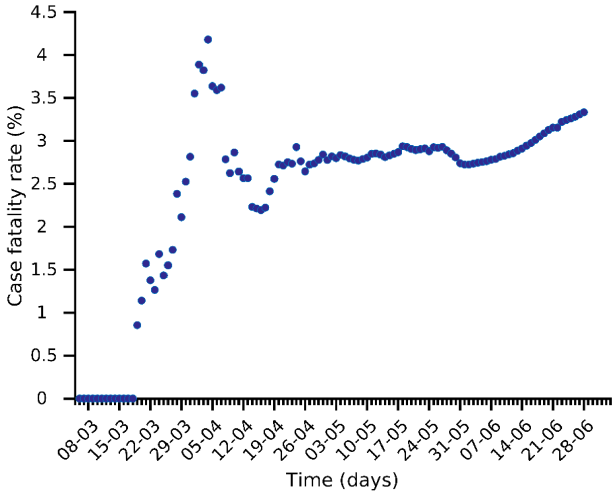


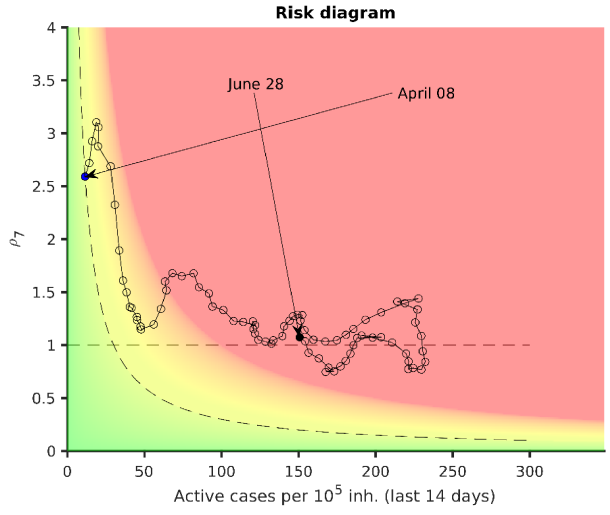


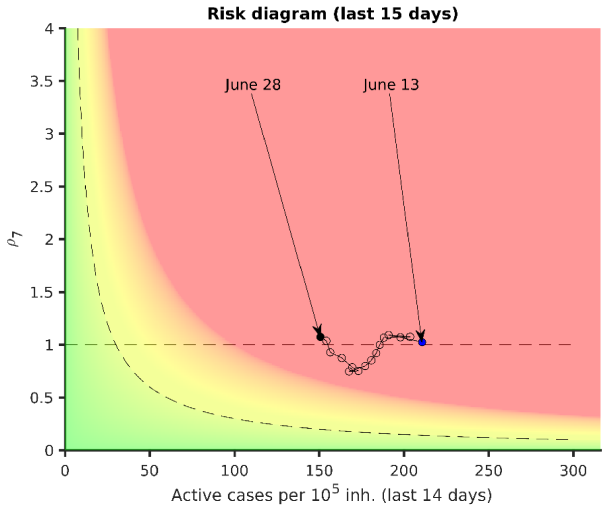




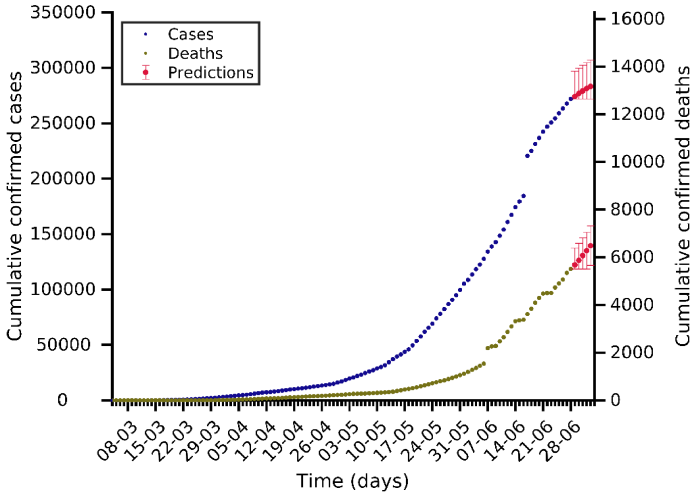


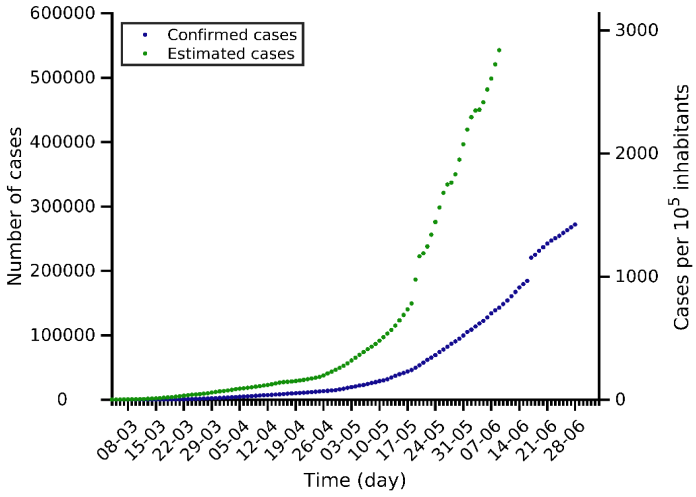


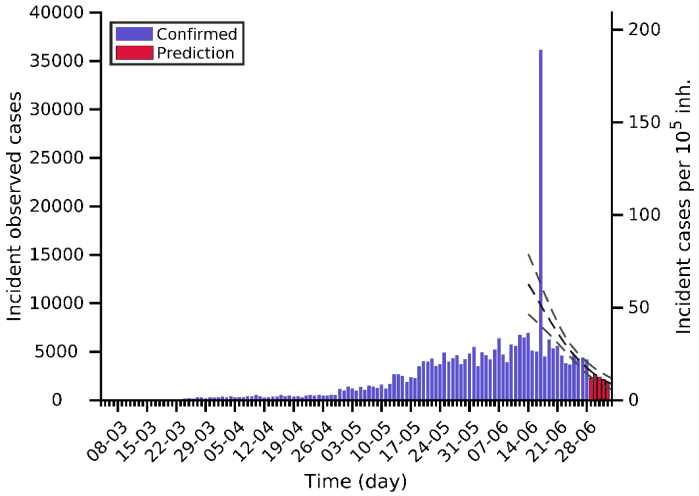


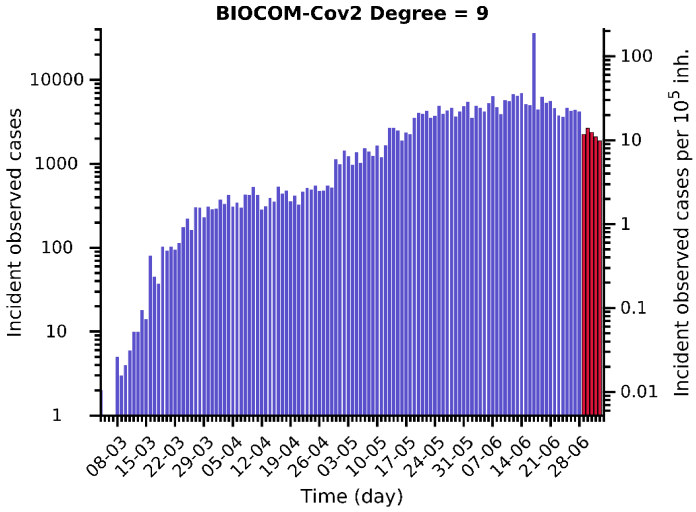


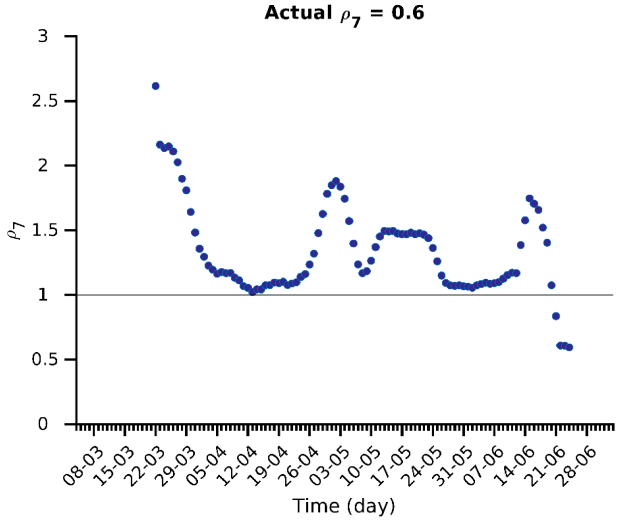
Chile 28-06-2020. Population: 19.1M. Current cumulative incidence: 1423/10⁵

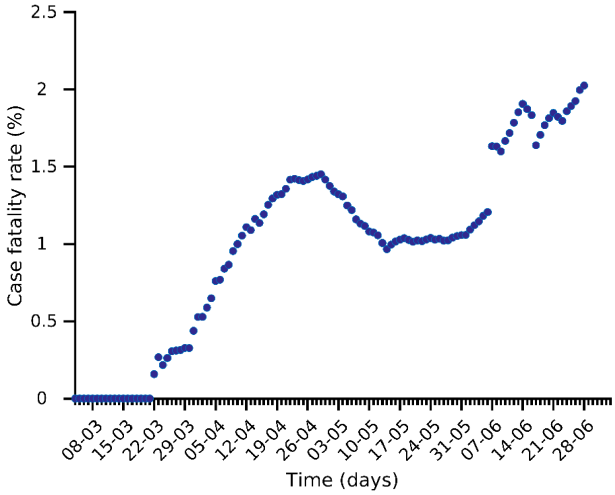


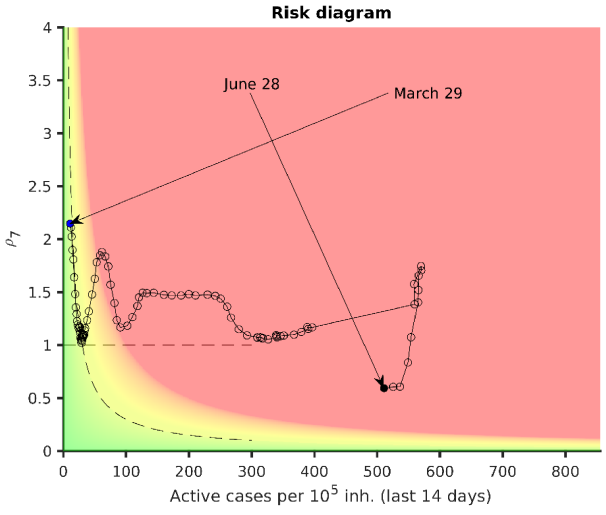


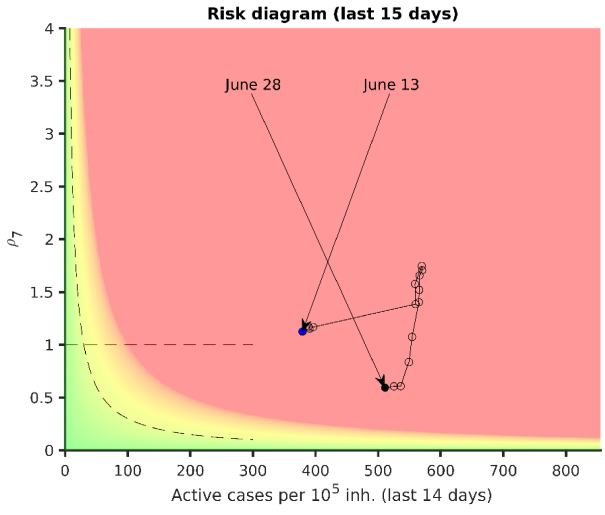




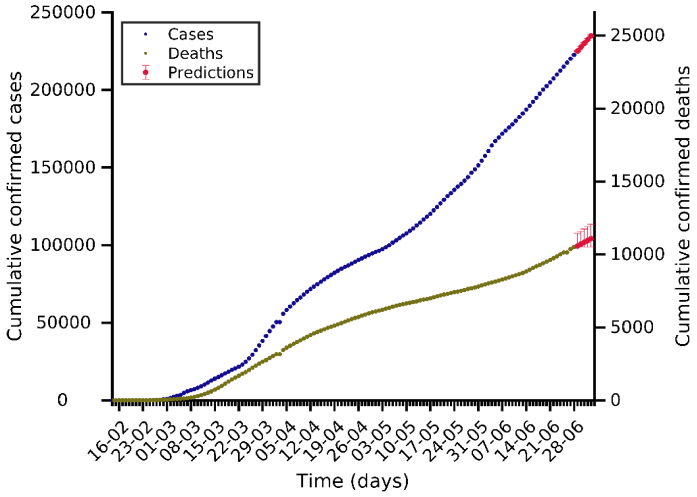


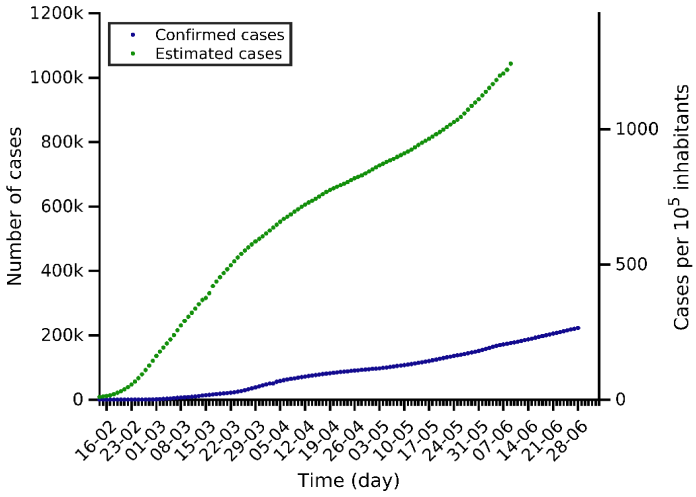


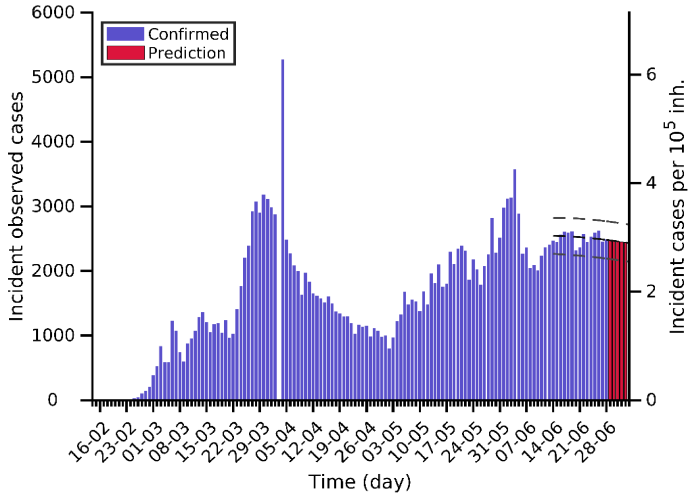


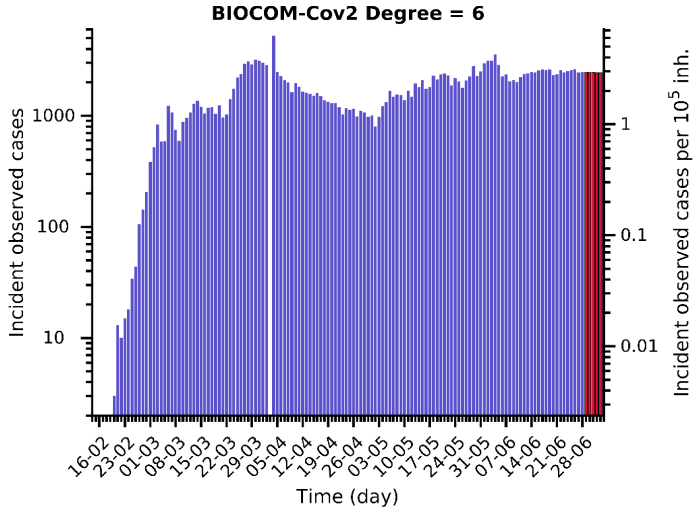


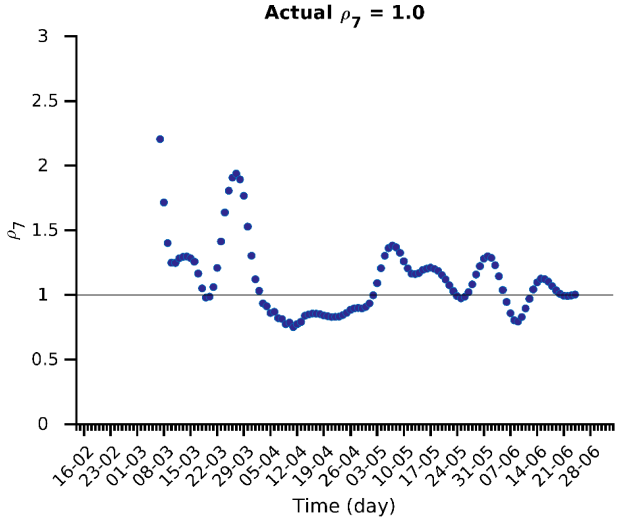
Iran 28-06-2020. Population: 84.0M. Current cumulative incidence: 265/10⁵

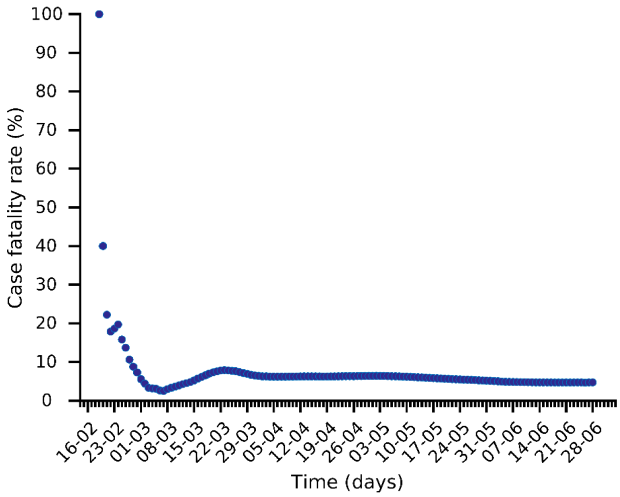


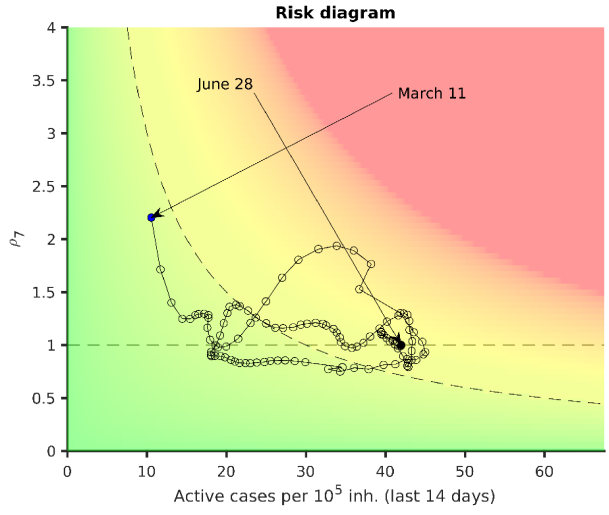


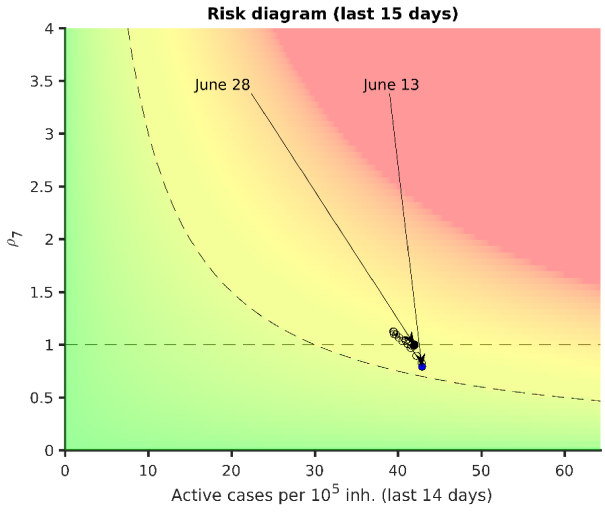




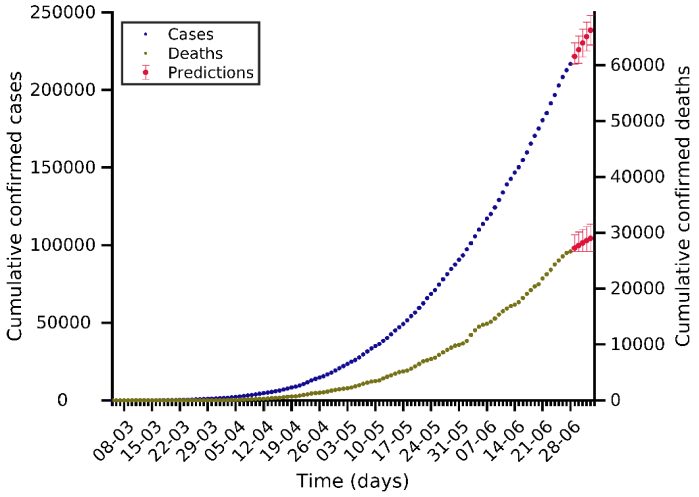


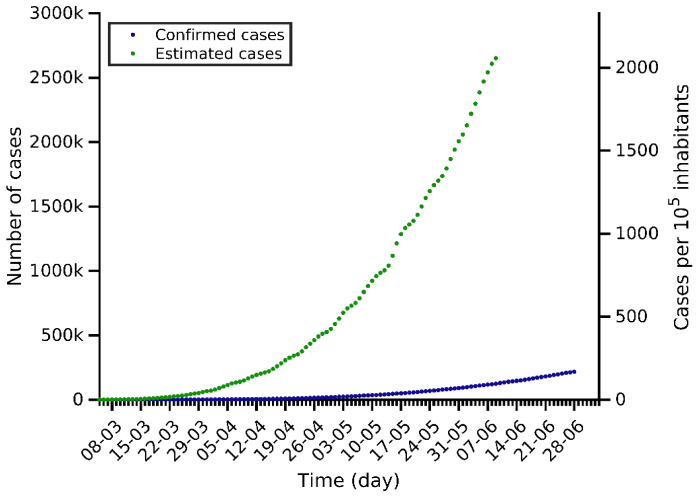


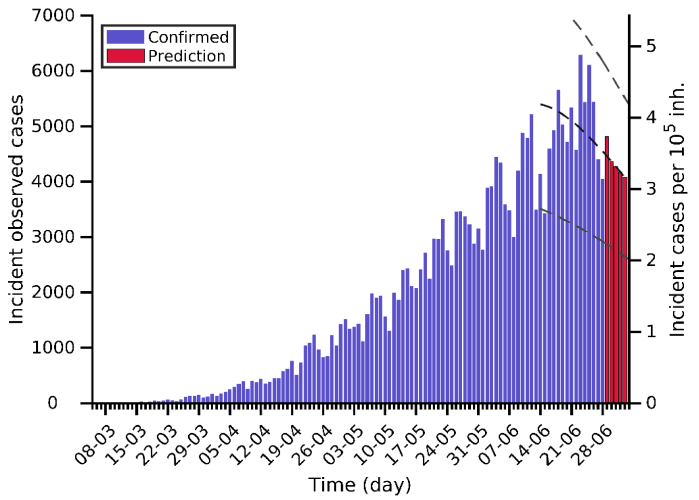


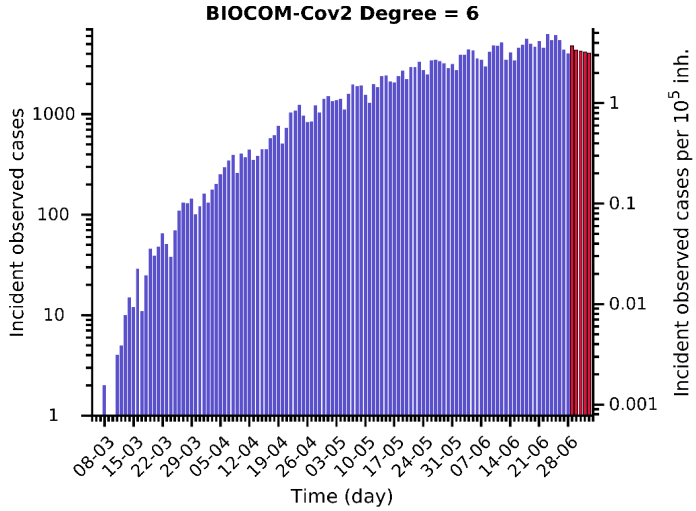


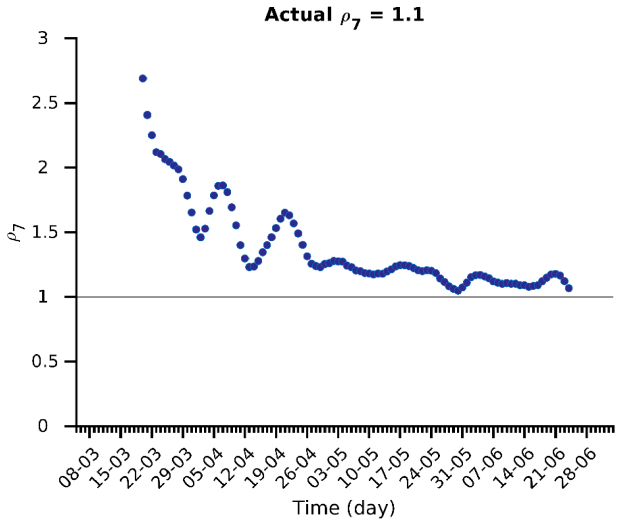
Mexico 28-06-2020. Population: 128.9M. Current cumulative incidence: 168/10⁵

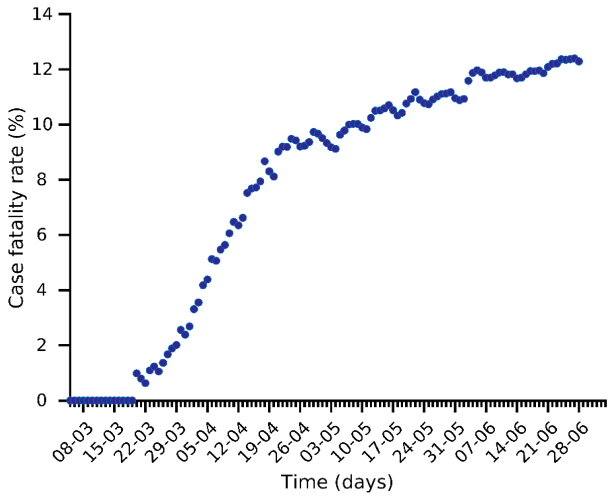


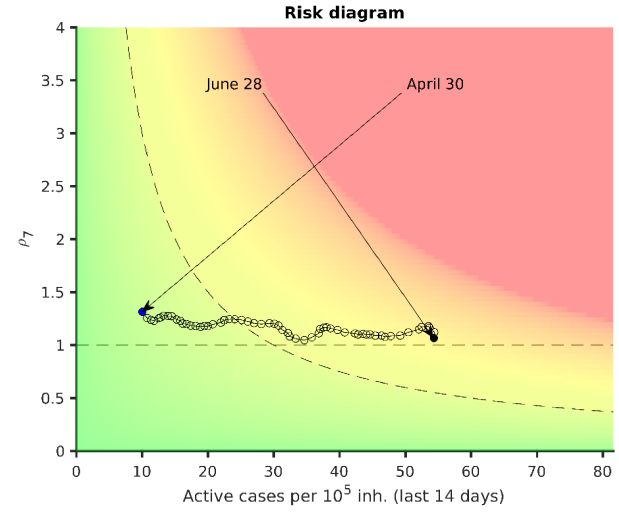


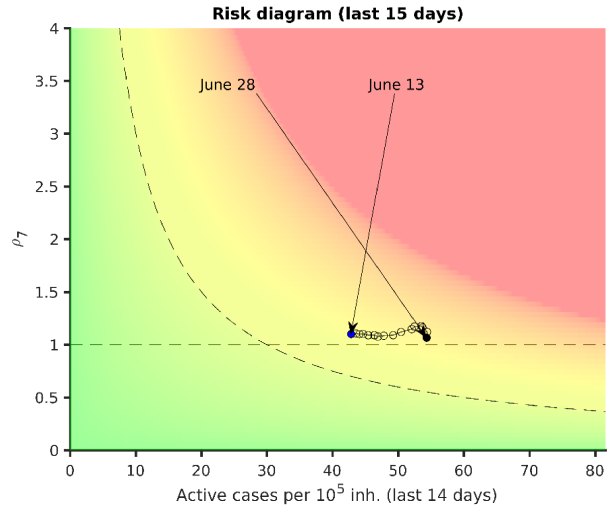




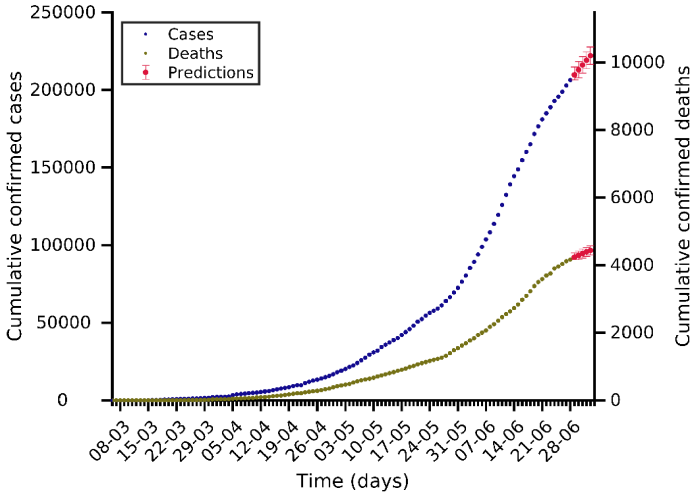


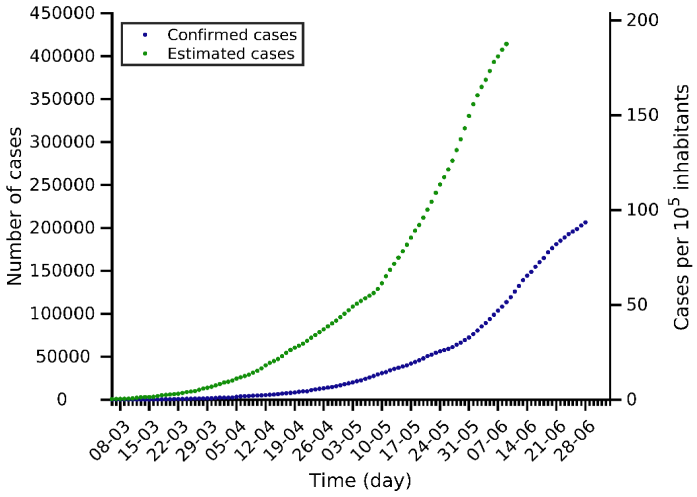


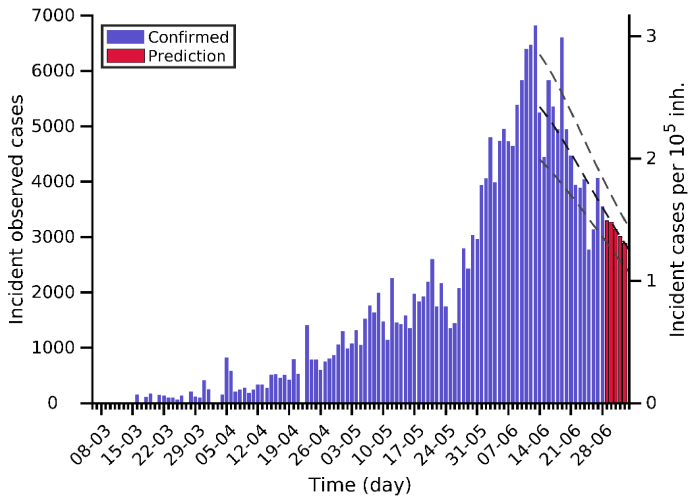


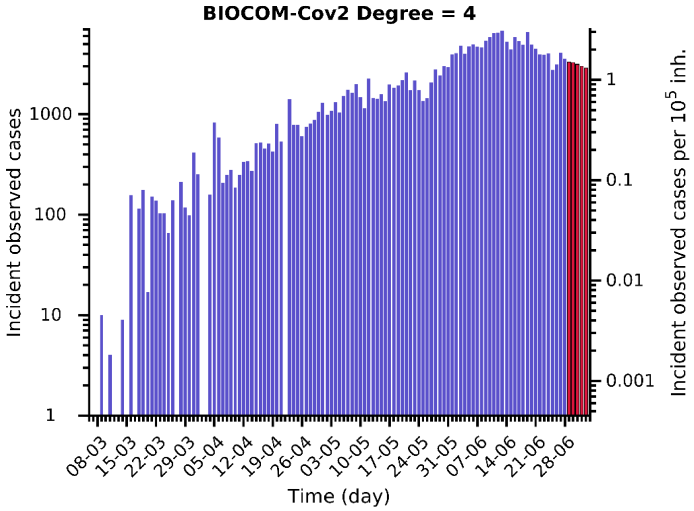


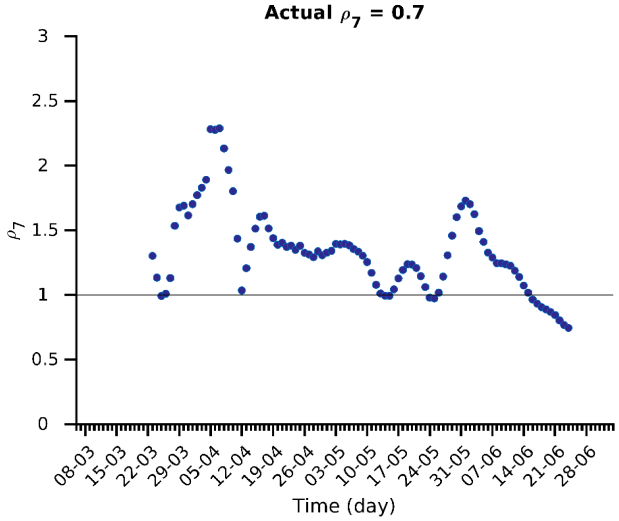
Pakistan 28-06-2020. Population: 220.9M. Current cumulative incidence: 93/10^5

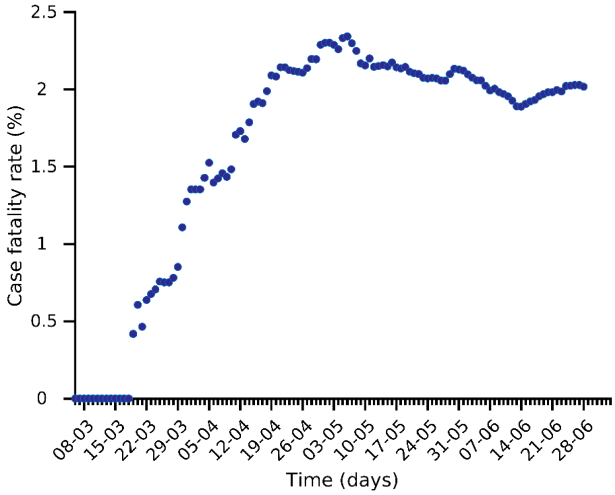


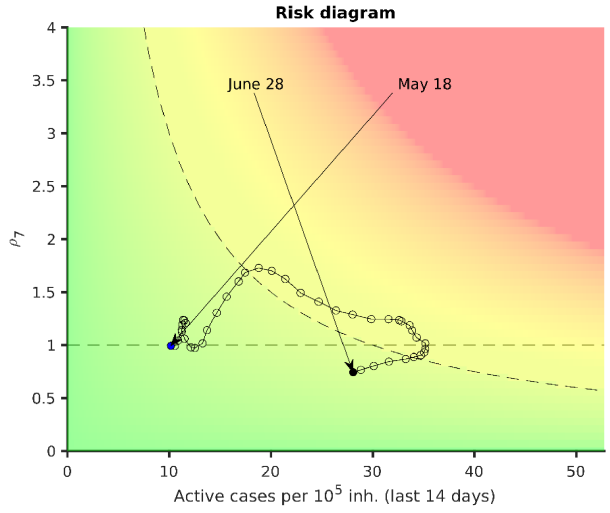


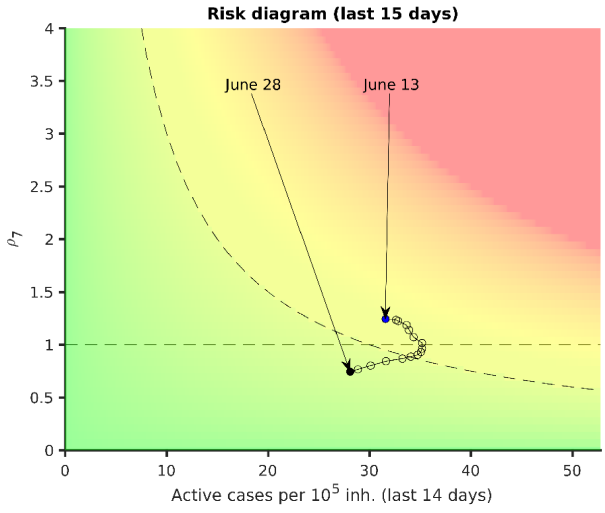




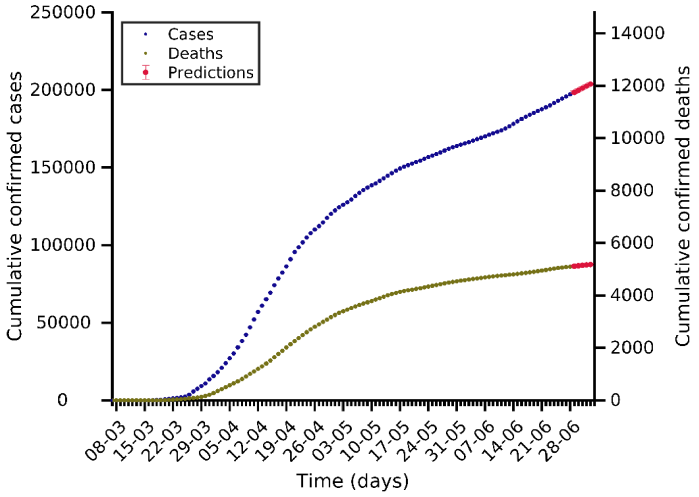


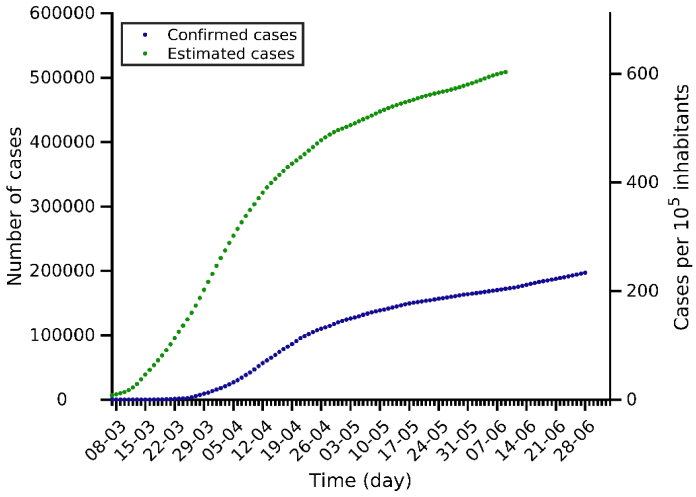


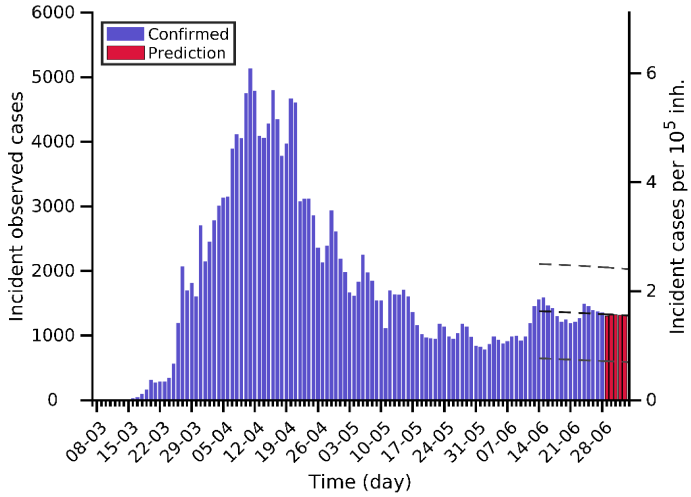


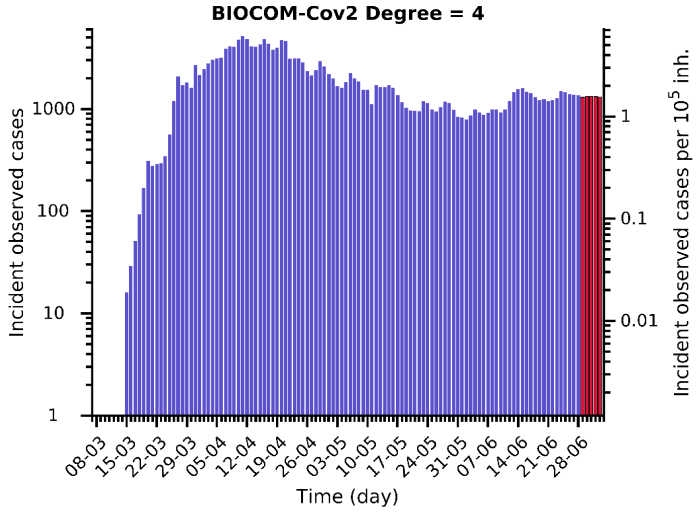


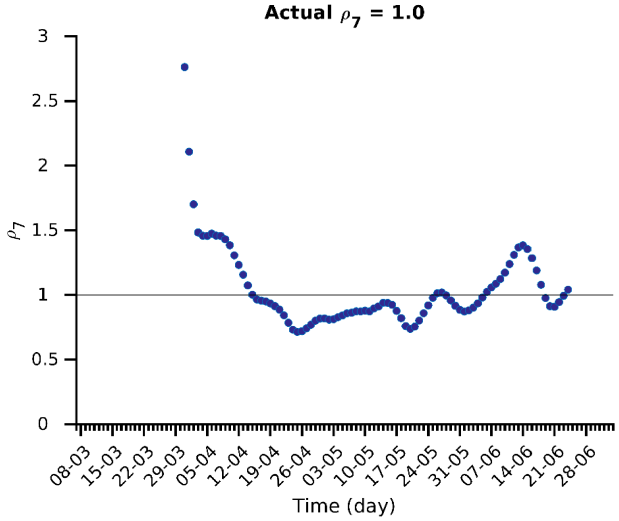
Turkey 28-06-2020. Population: 84.3M. Current cumulative incidence: 234/10⁵

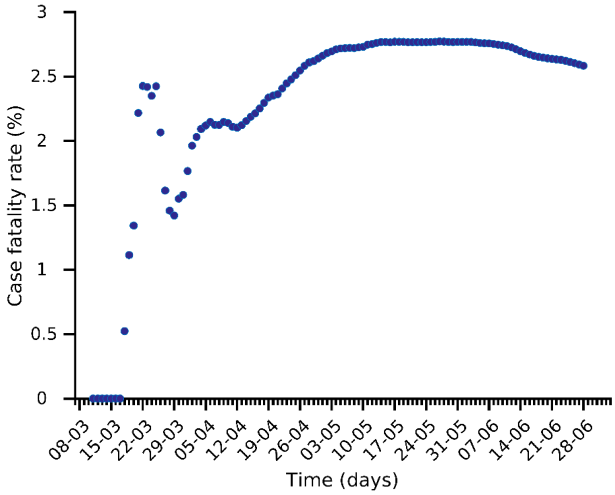


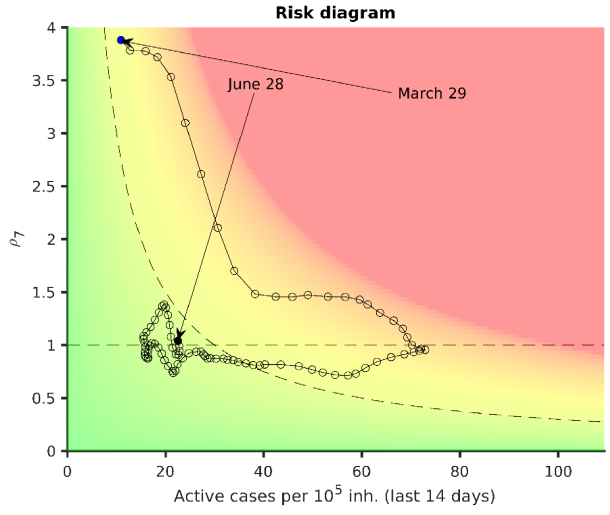


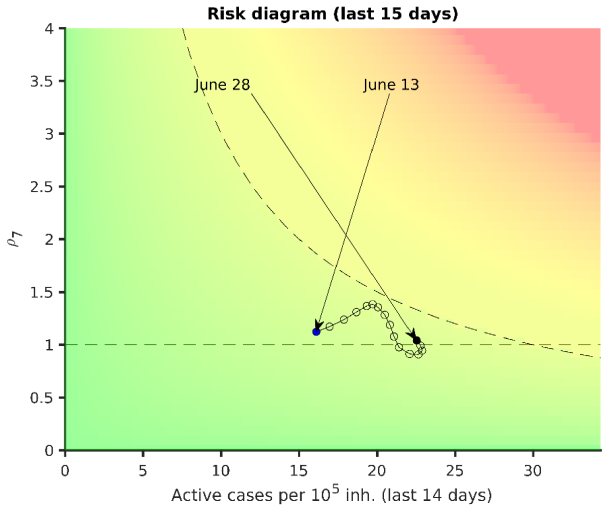




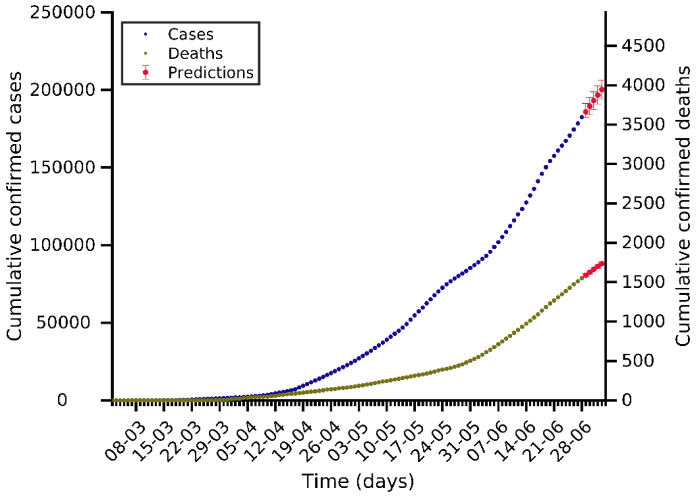


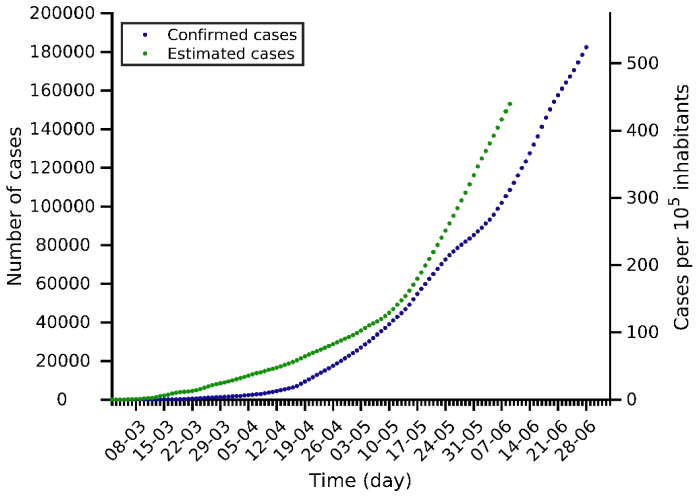


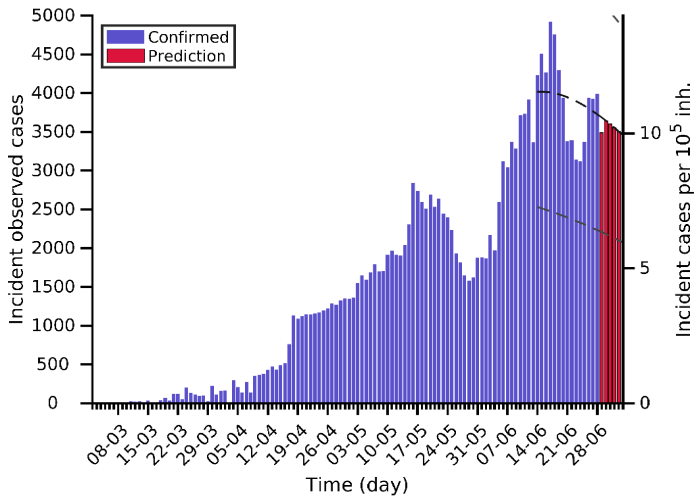


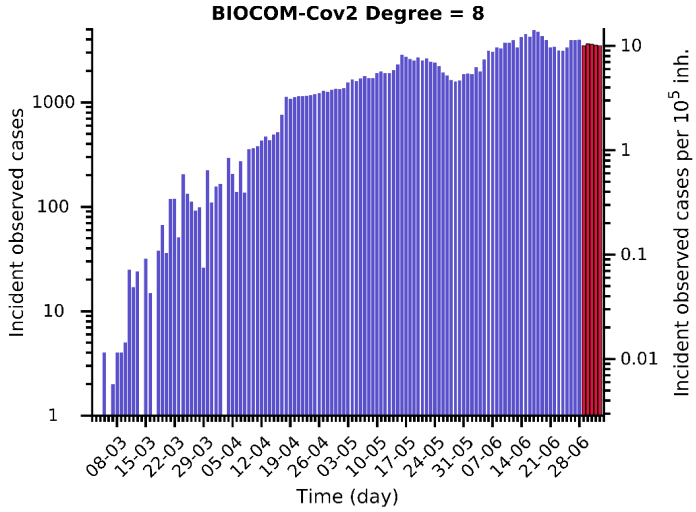


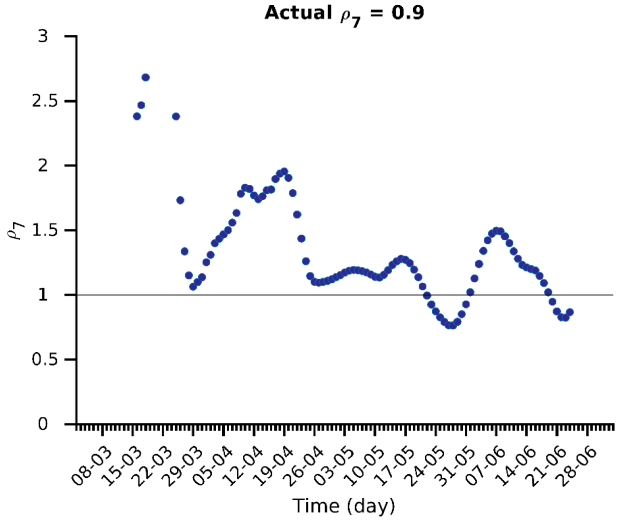
Saudi Arabia 28-06-2020. Population: 34.8M. Current cumulative incidence: 524/10

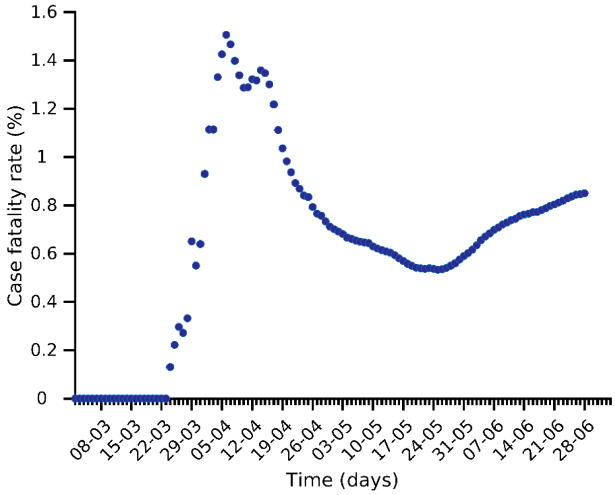


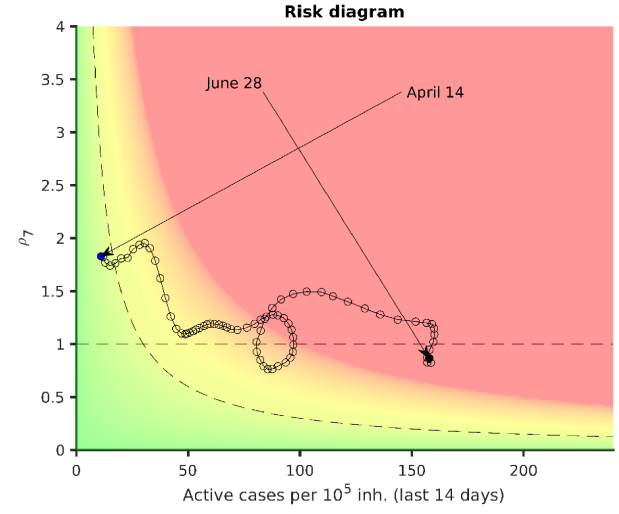


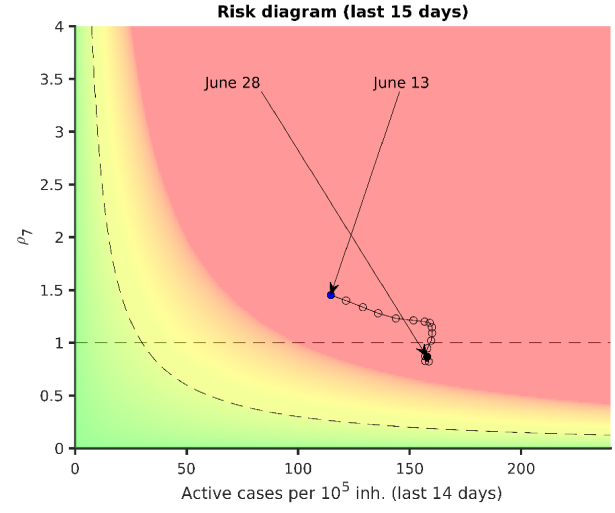




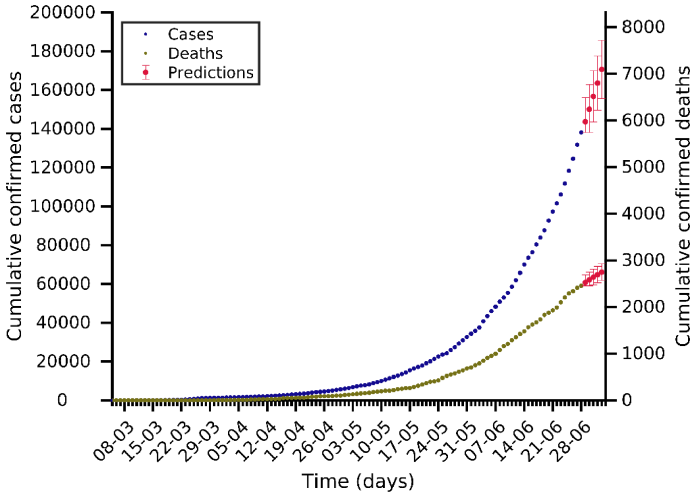


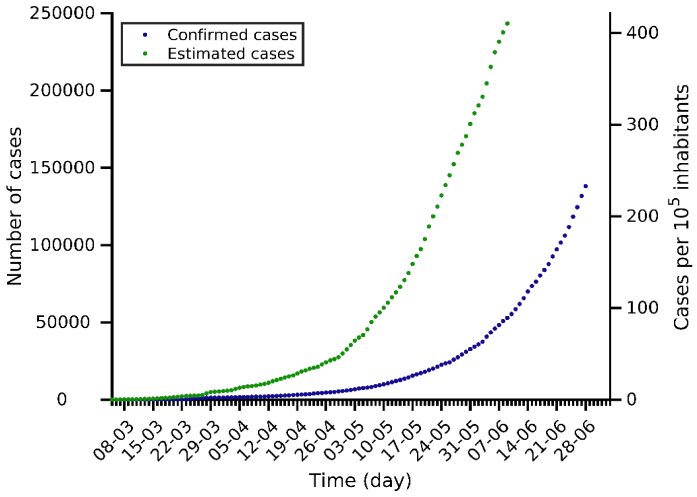


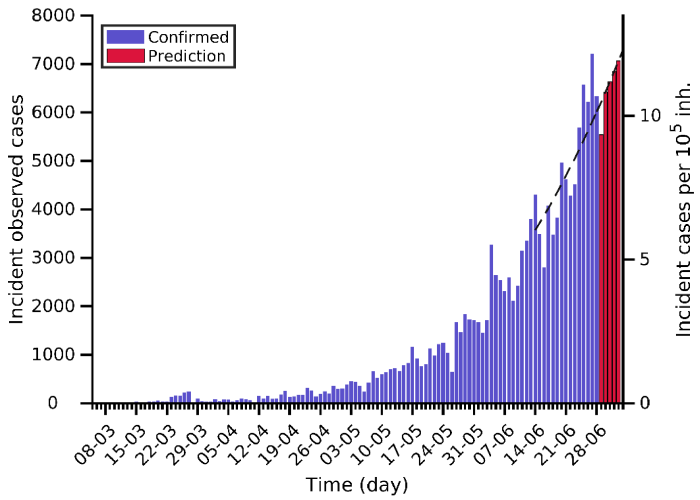


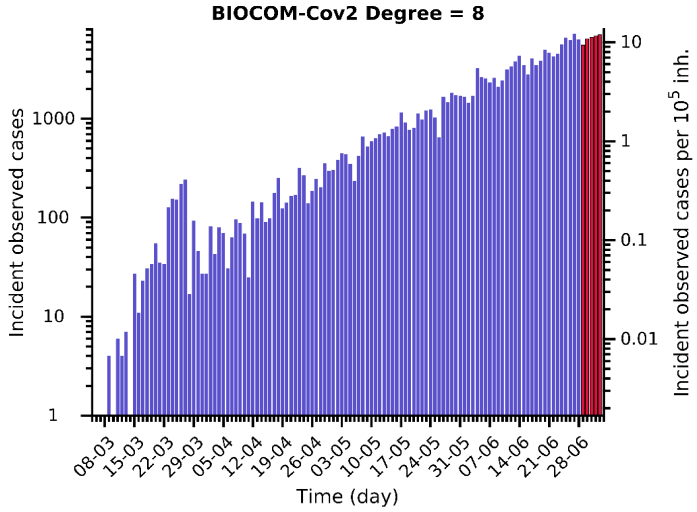


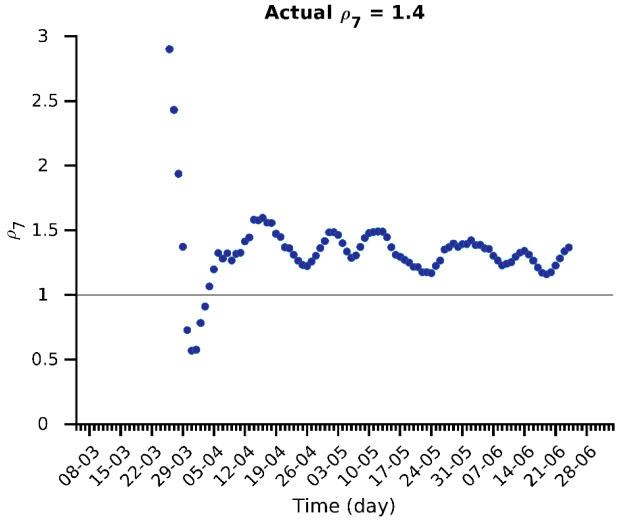
South Africa 28-06-2020. Population: 59.3M. Current cumulative incidence: 233/10^5

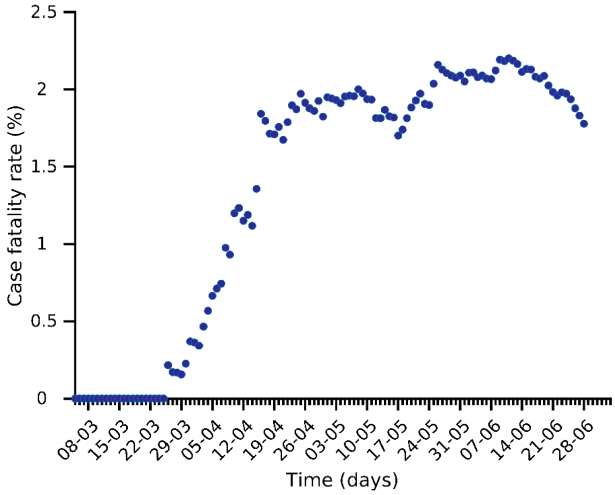


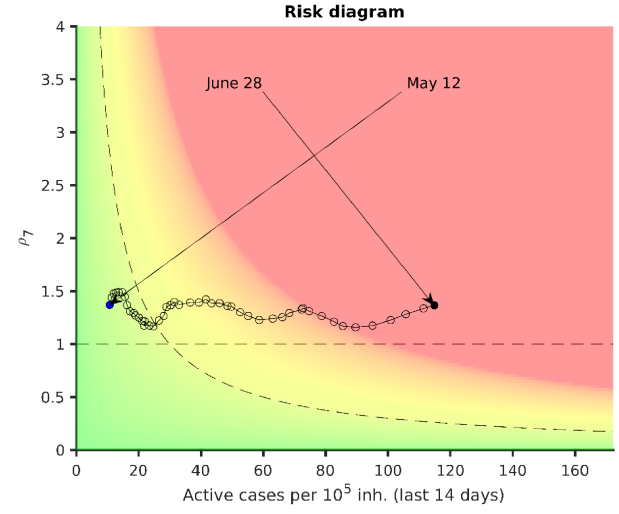


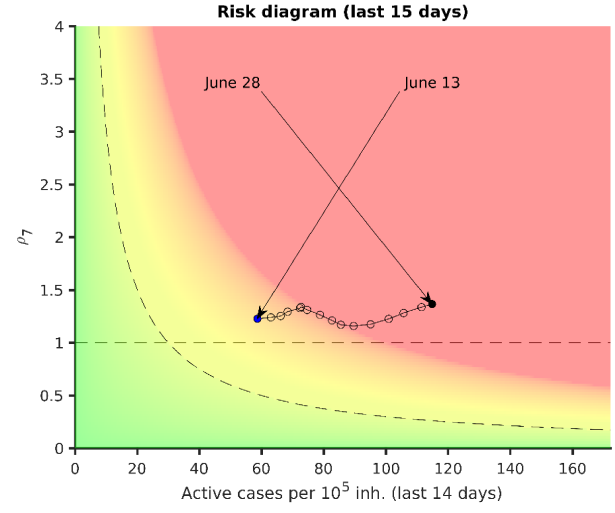




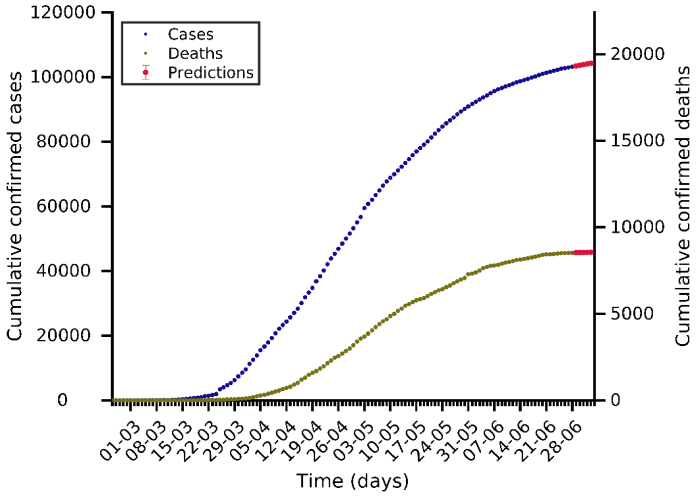


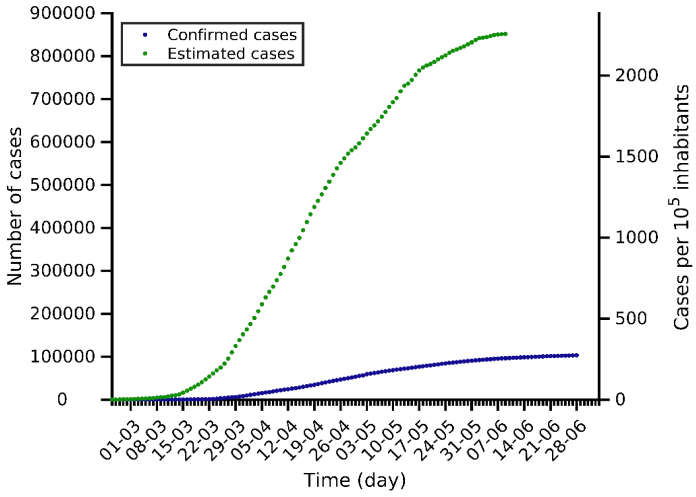


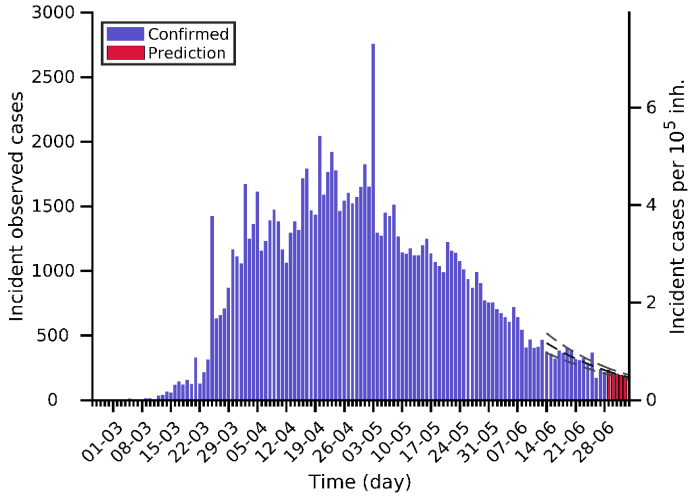


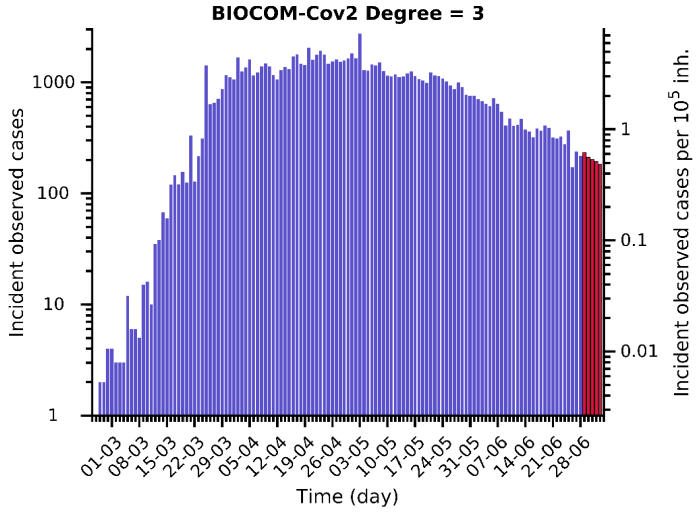


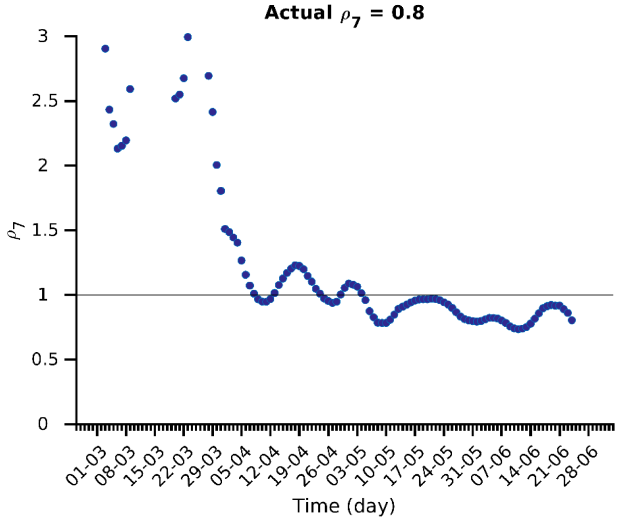
Canada 28-06-2020. Population: 37.7M. Current cumulative incidence: 274/10⁵

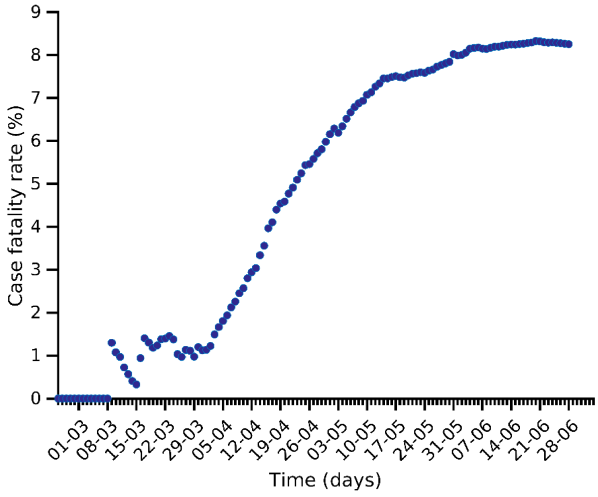


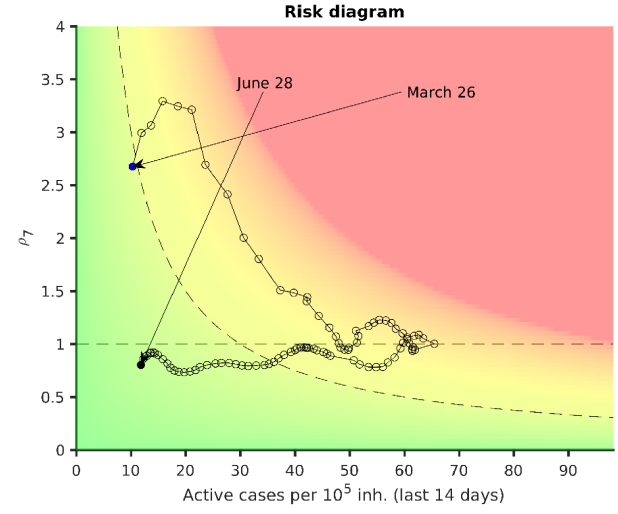


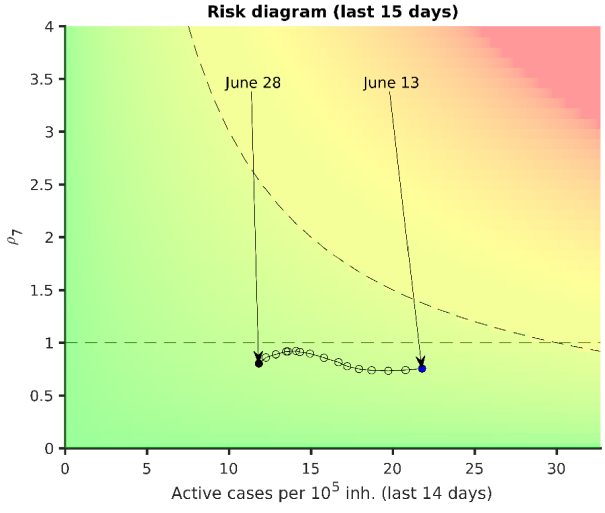




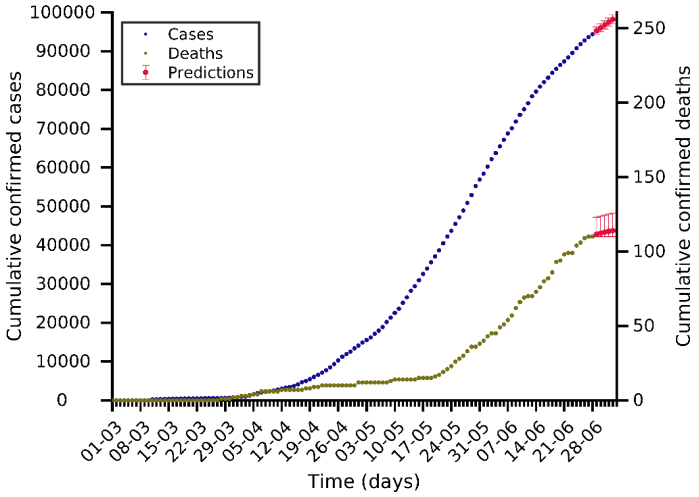


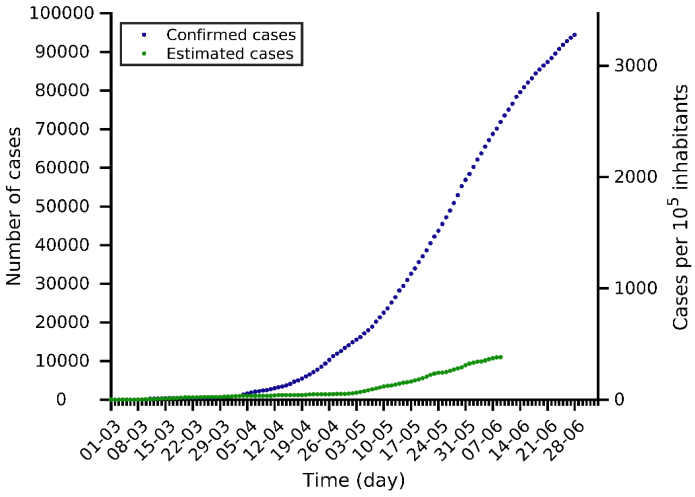


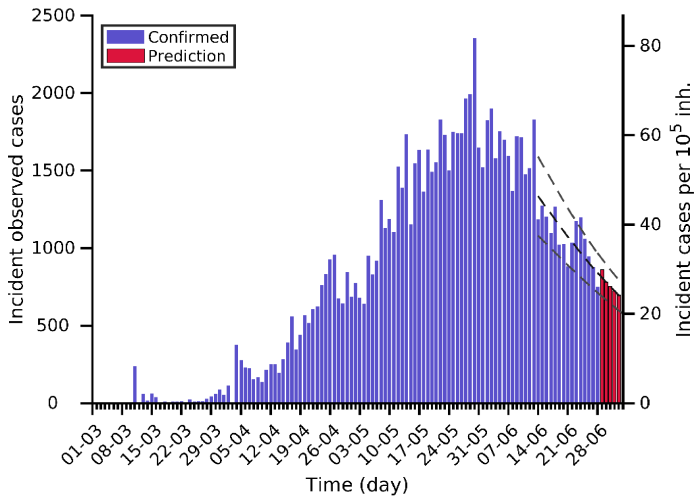


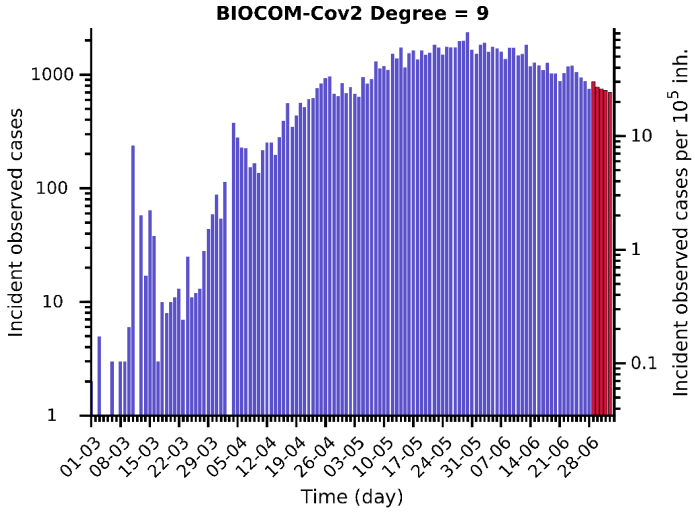


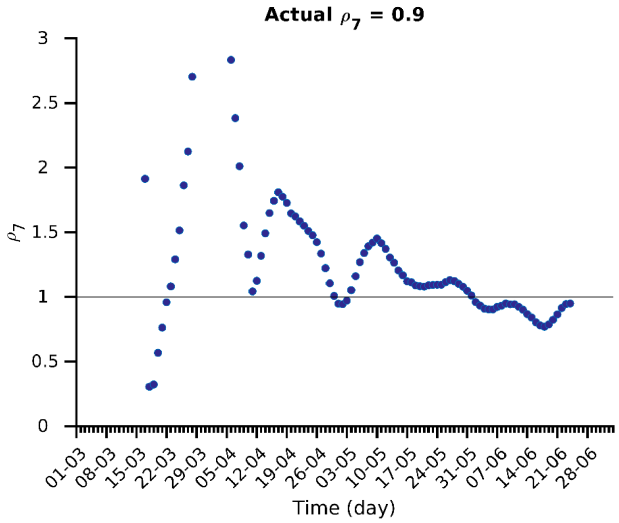
Qatar 28-06-2020. Population: 2.9M. Current cumulative incidence: 3277/10⁵

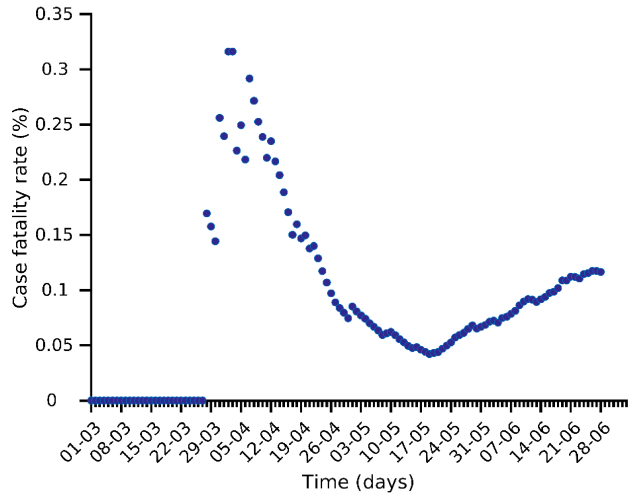


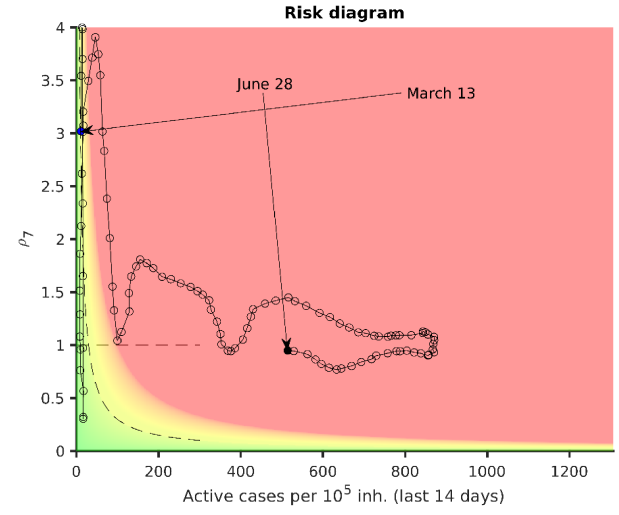


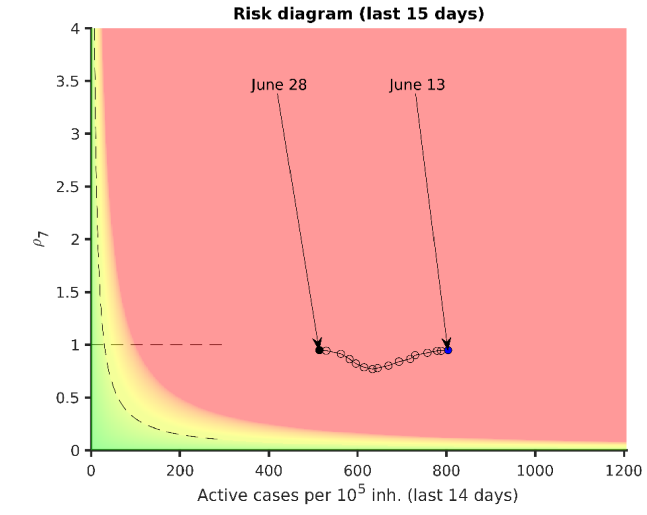




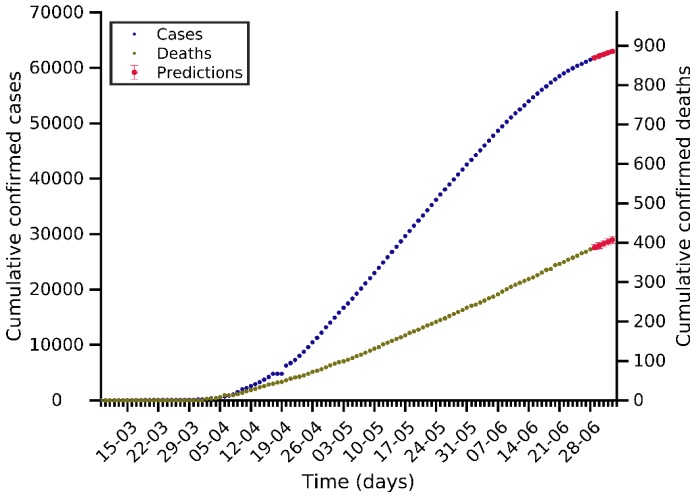


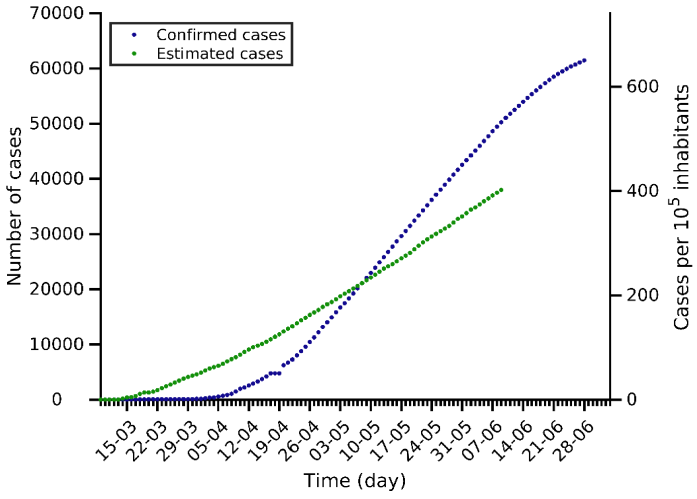


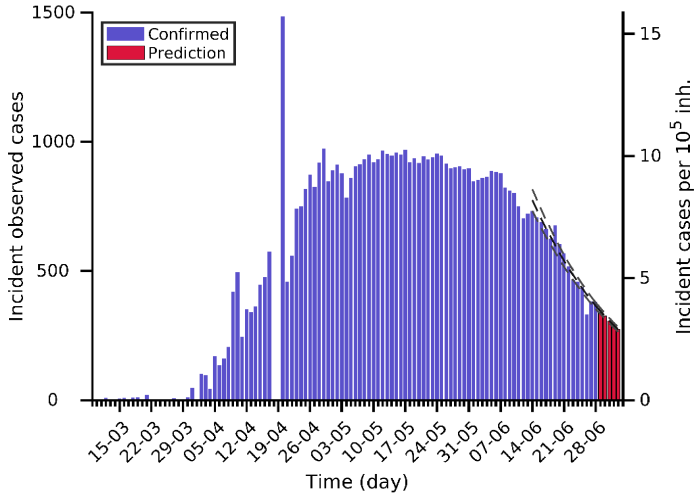


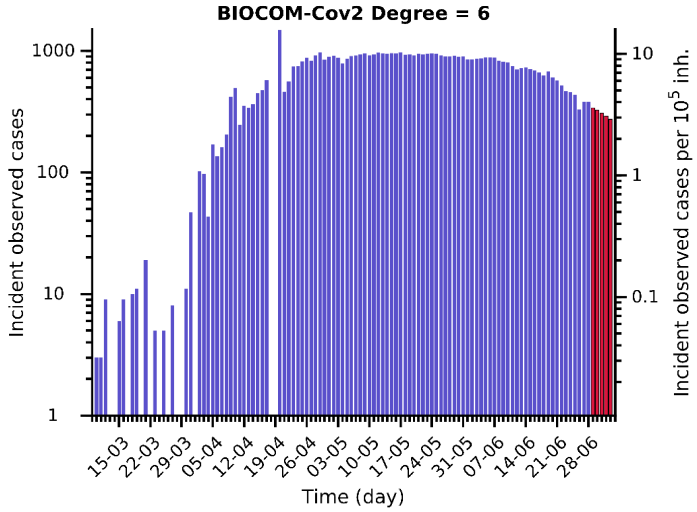


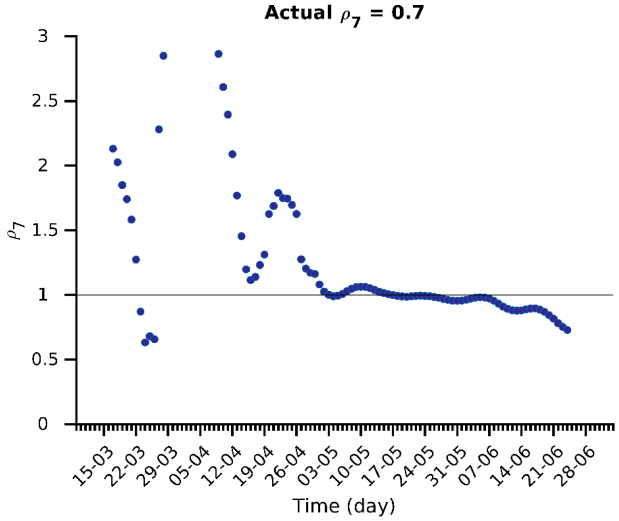
Belarus 28-06-2020. Population: 9.4M. Current cumulative incidence: 651/10^5

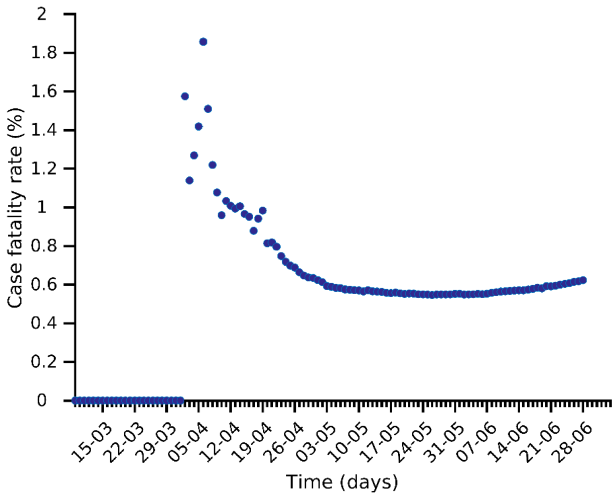


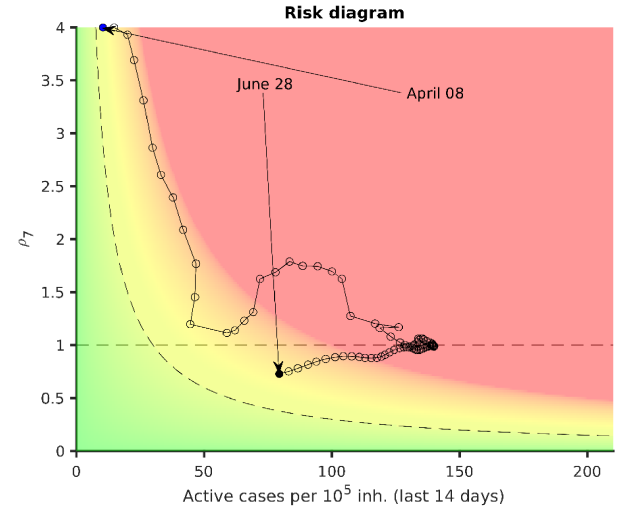


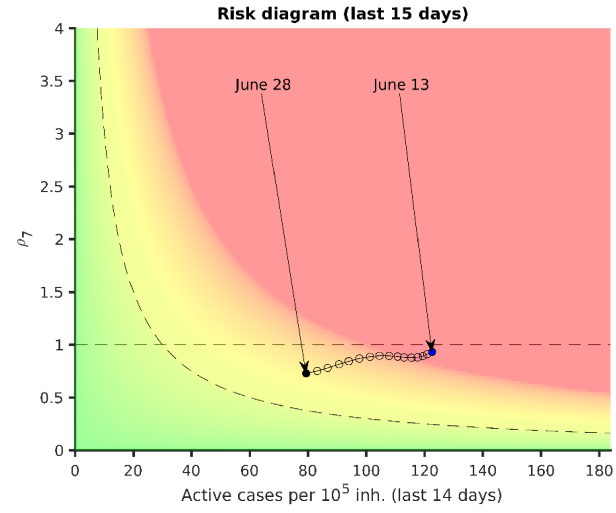




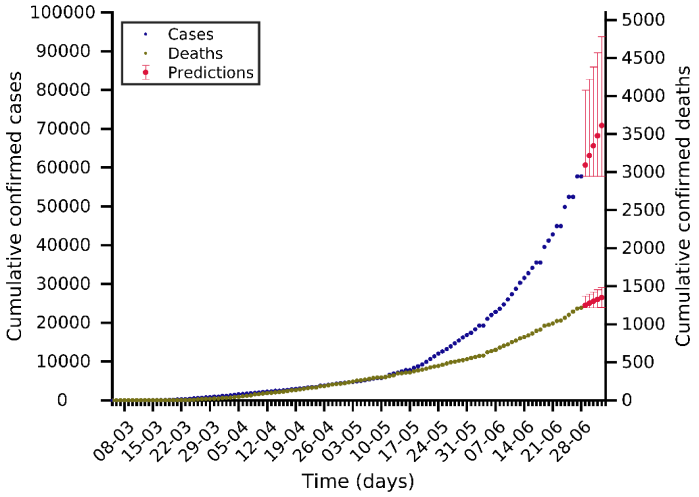


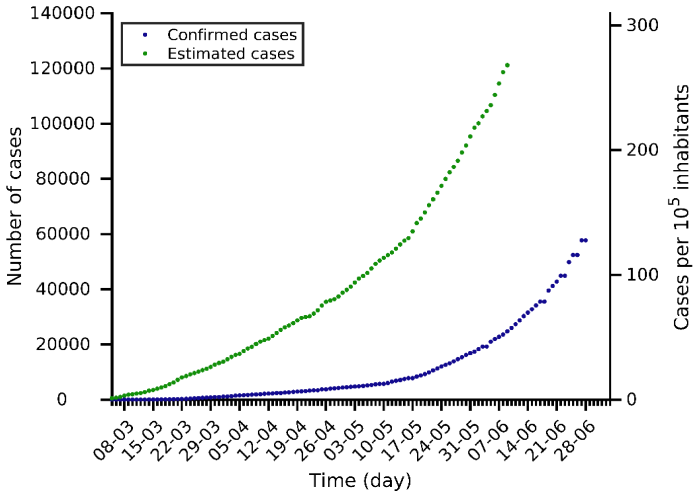


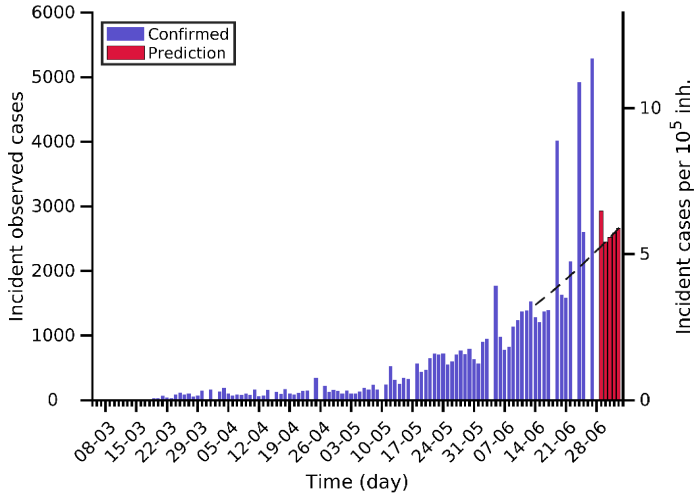


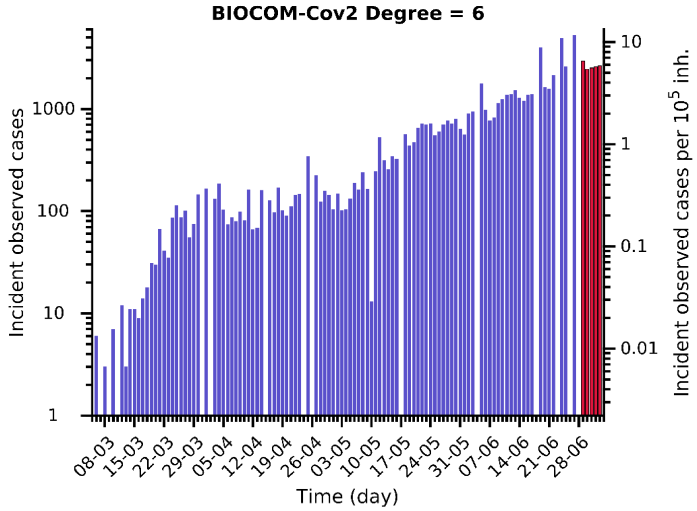


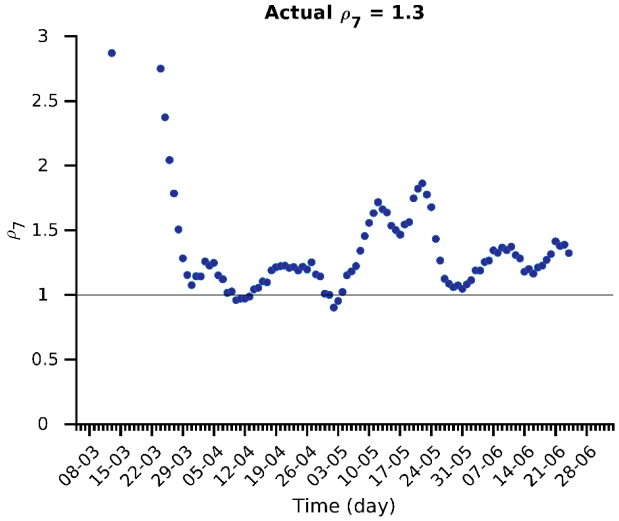
Argentina 28-06-2020. Population: 45.2M. Current cumulative incidence: 128/10^5

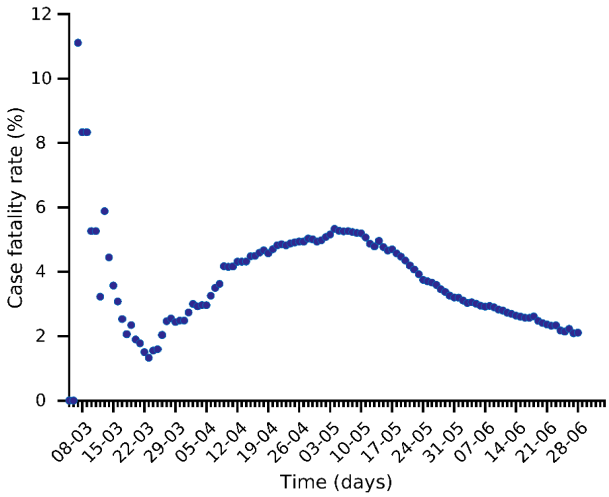


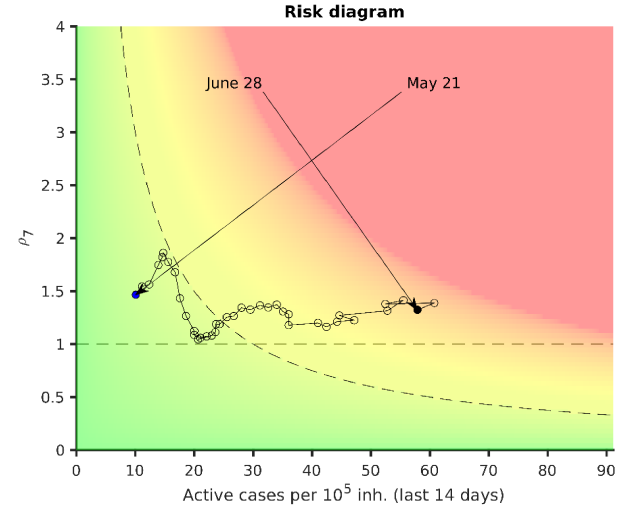


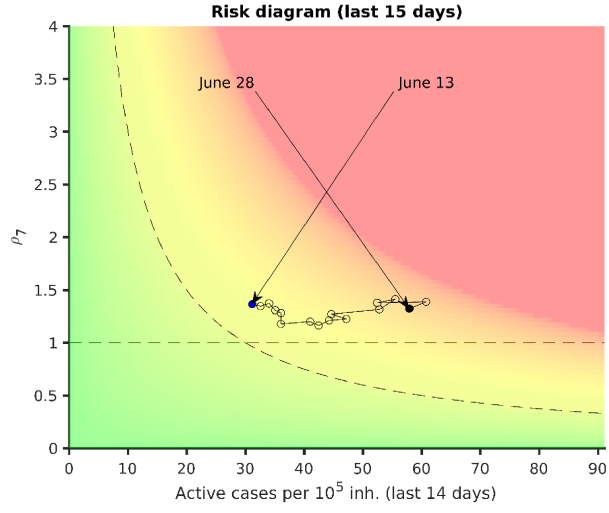




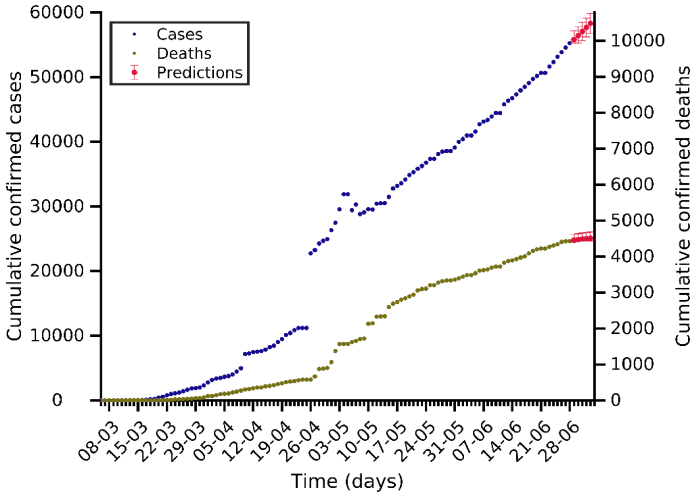


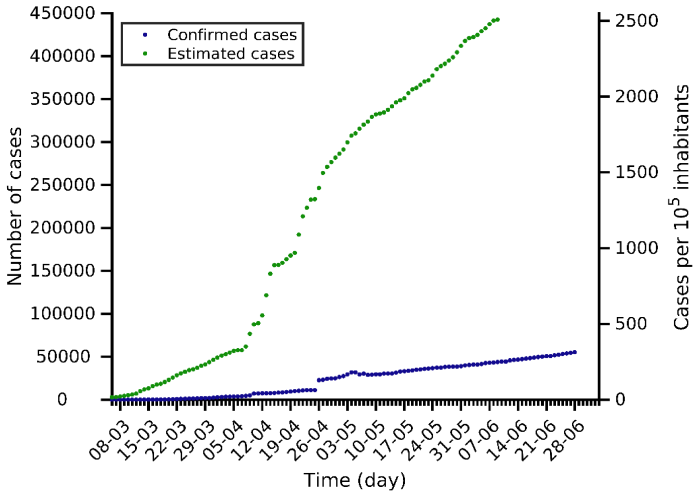


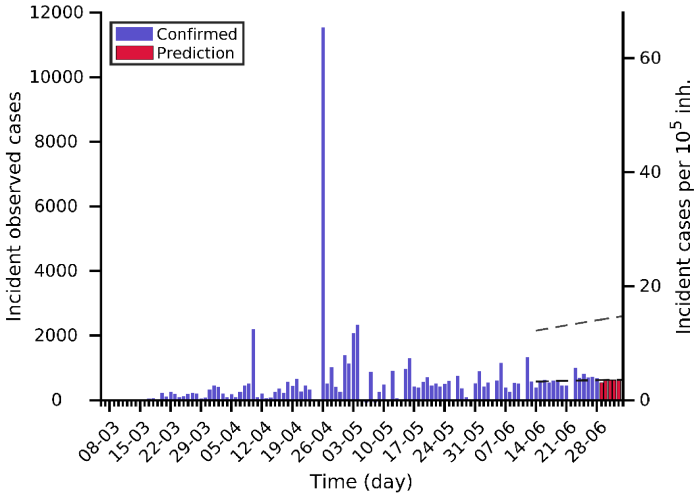


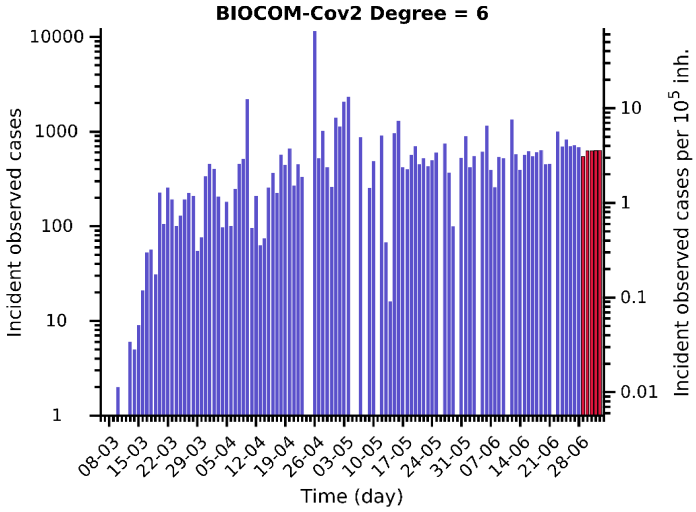


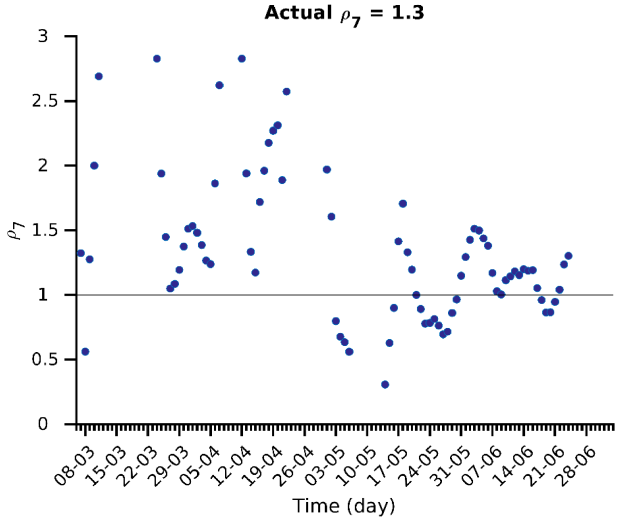
Ecuador 28-06-2020. Population: 17.6M. Current cumulative incidence: 313/10⁵

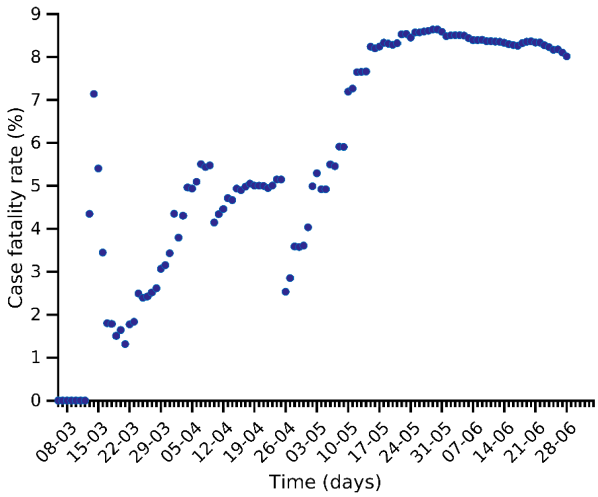


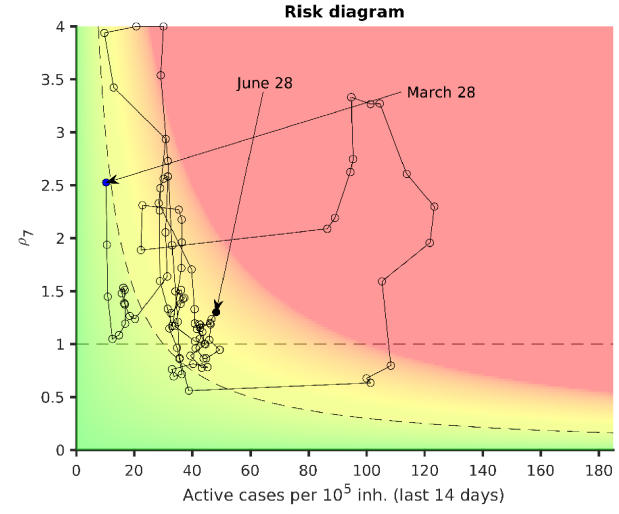


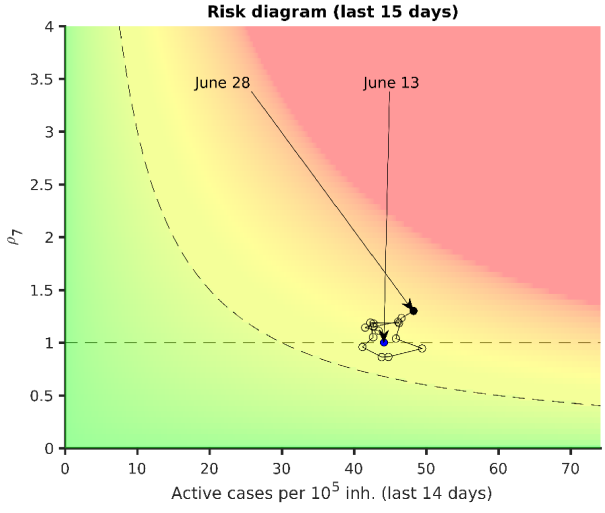




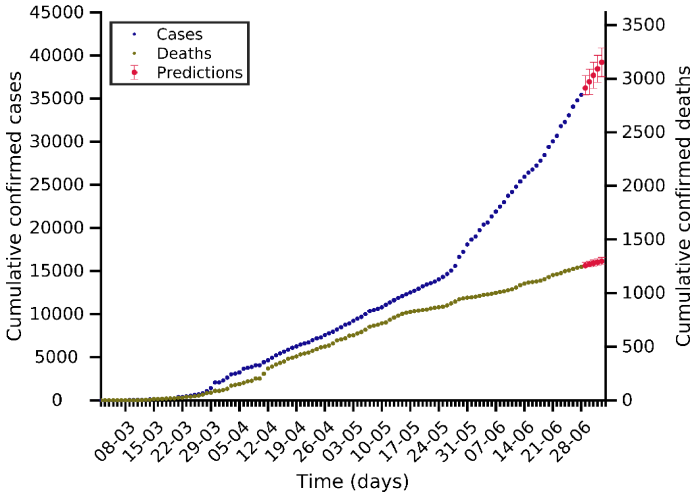


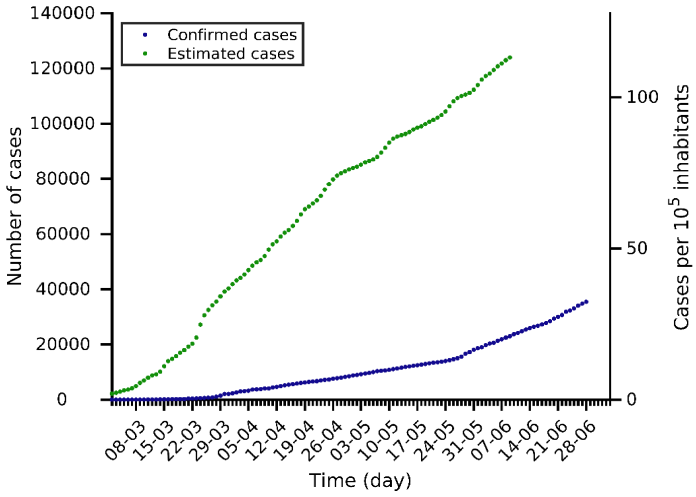


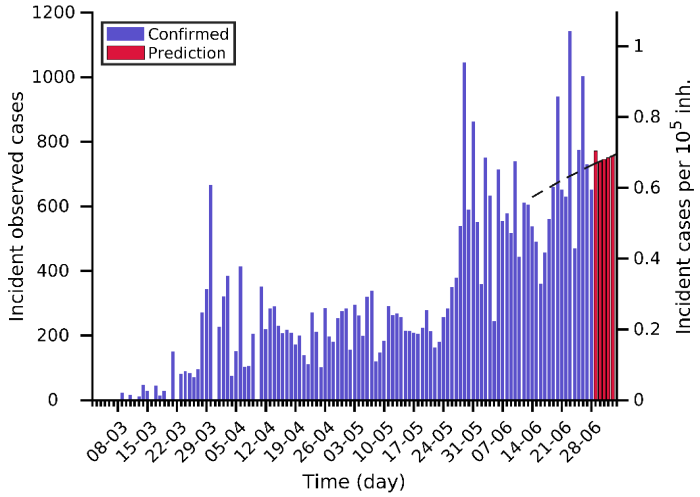


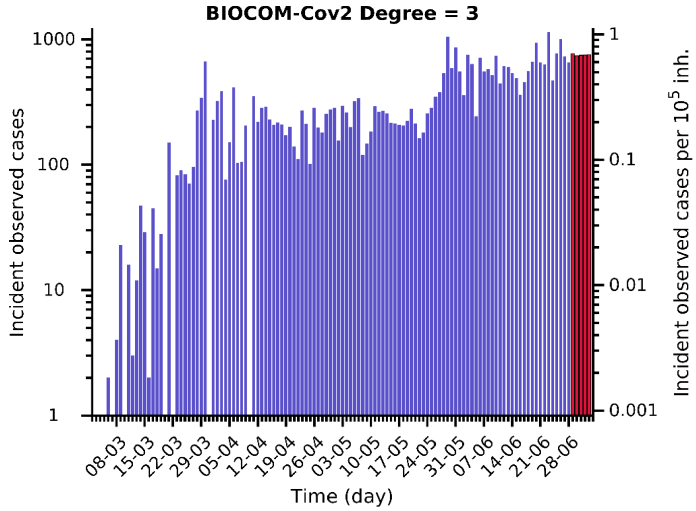


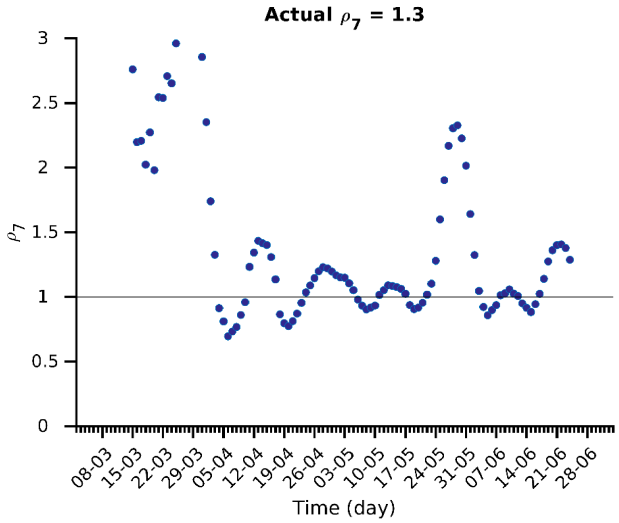
Philippines 28-06-2020. Population: 109.6M. Current cumulative incidence: 32/10^5

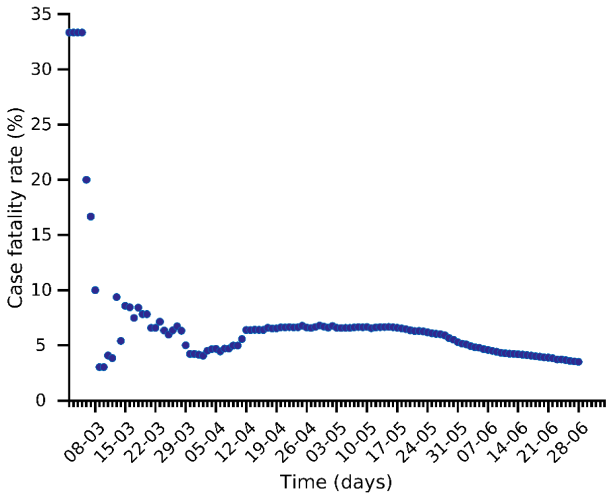


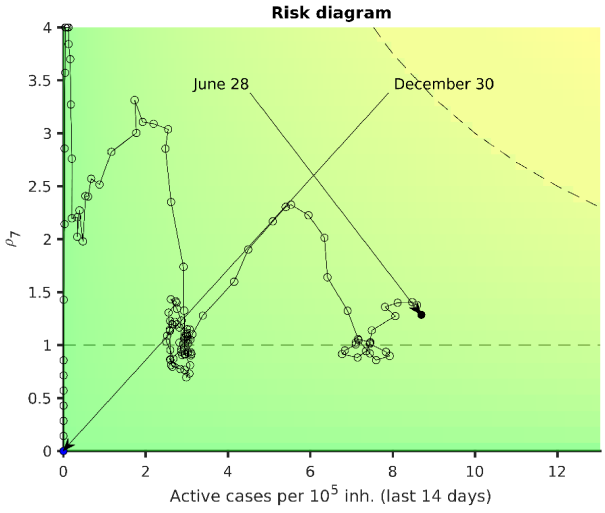


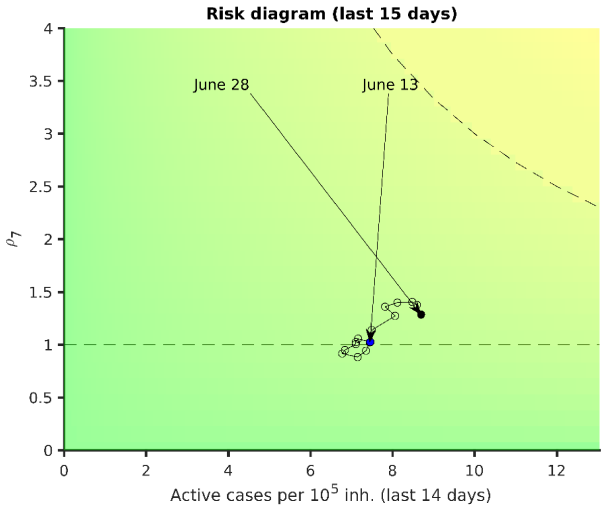




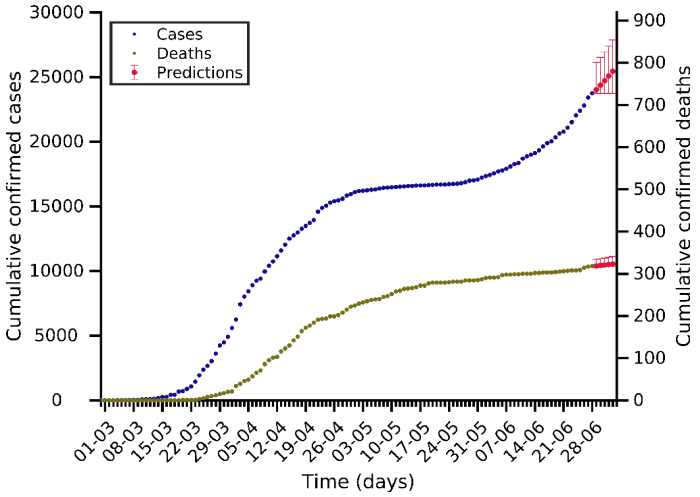


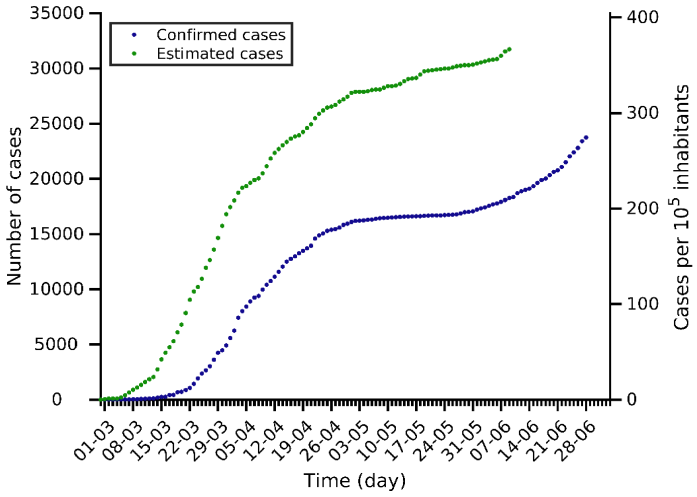


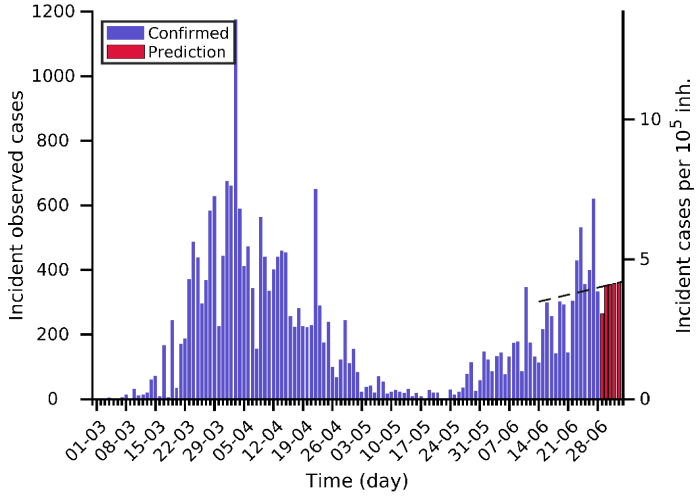


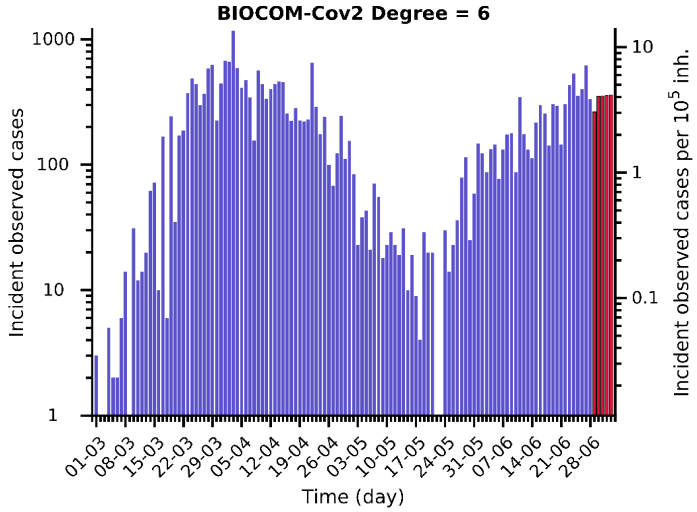


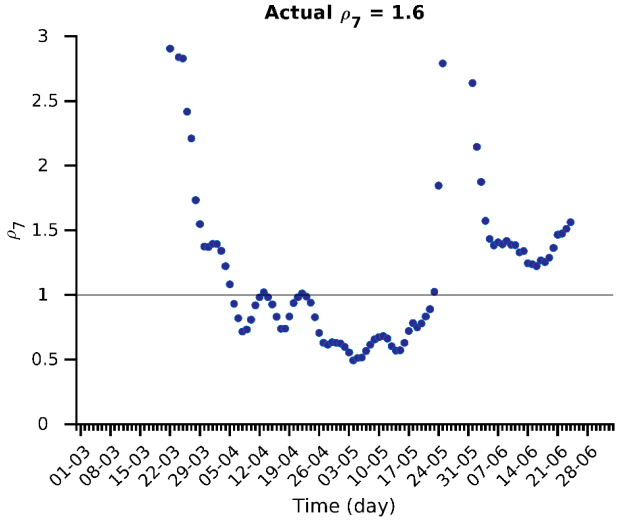
Israel 28-06-2020. Population: 8.7M. Current cumulative incidence: 274/10⁵

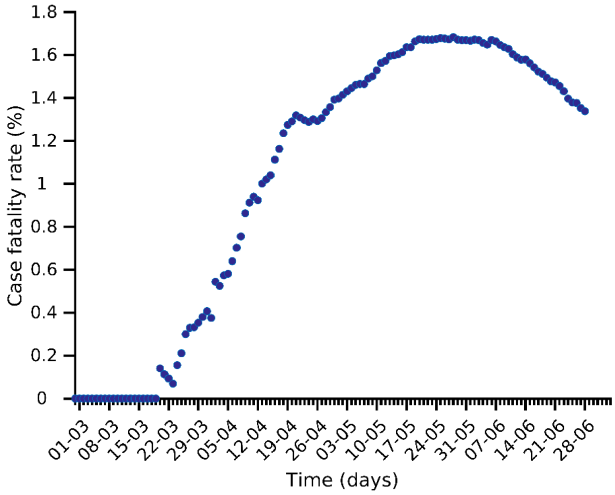


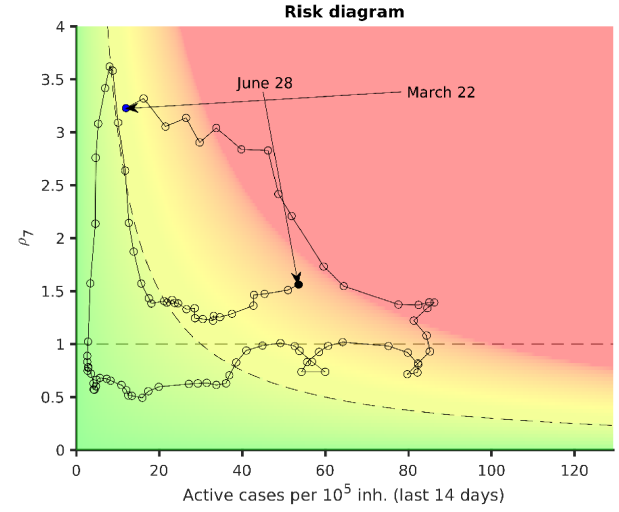


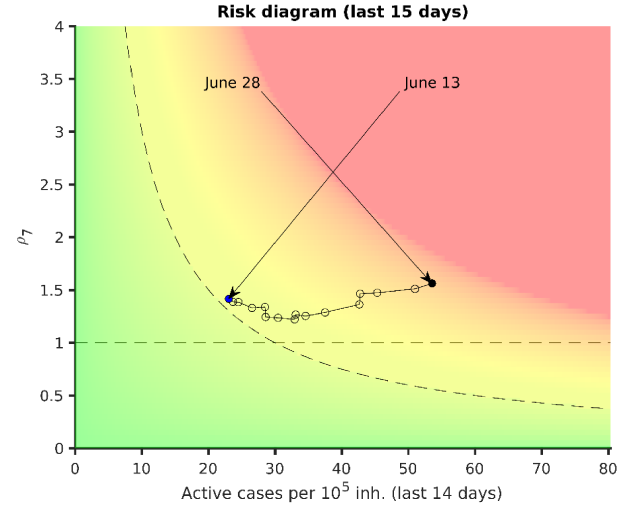




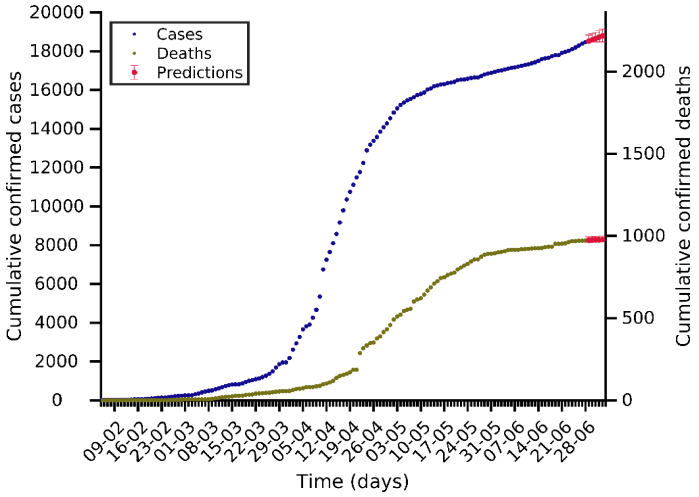


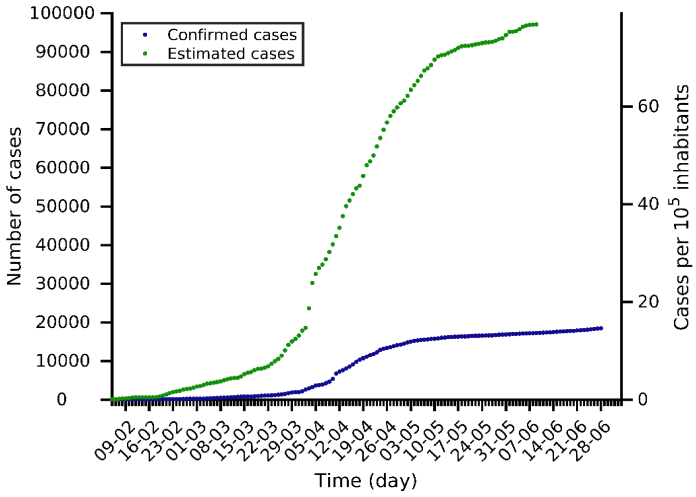


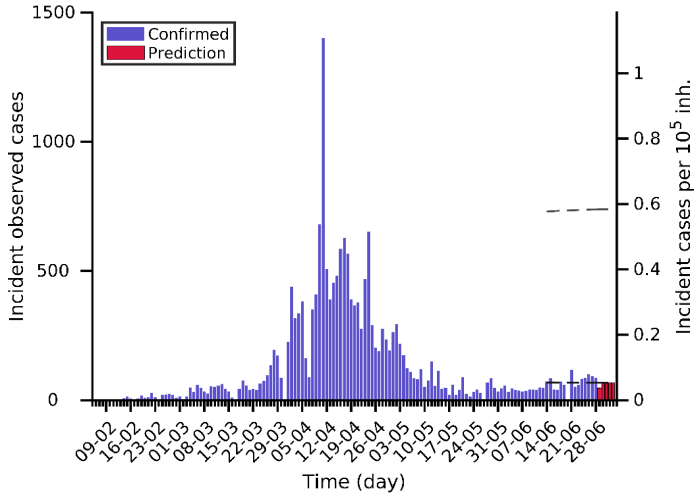


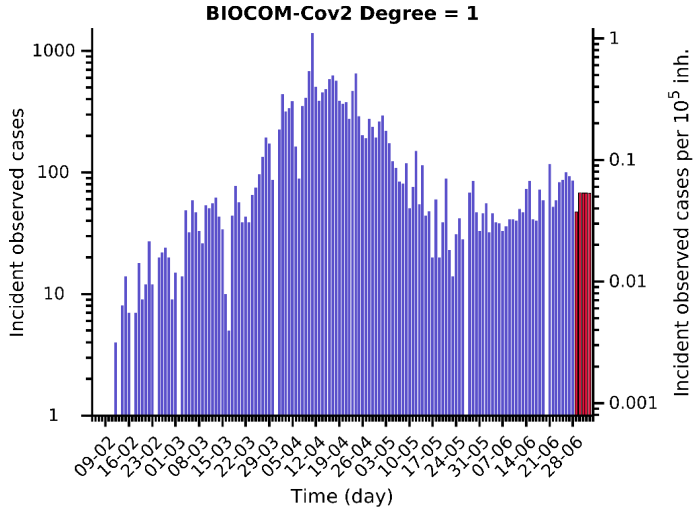


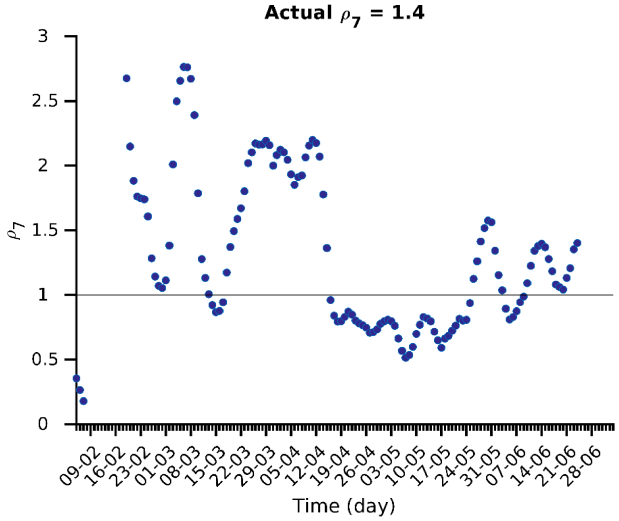
Japan 28-06-2020. Population: 126.5M. Current cumulative incidence: $15/10^5$

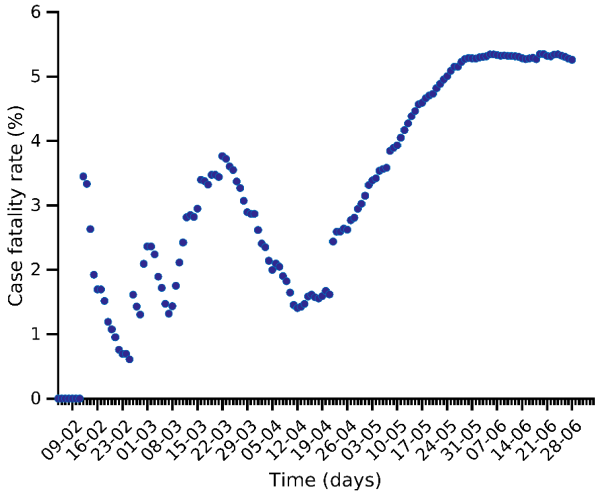


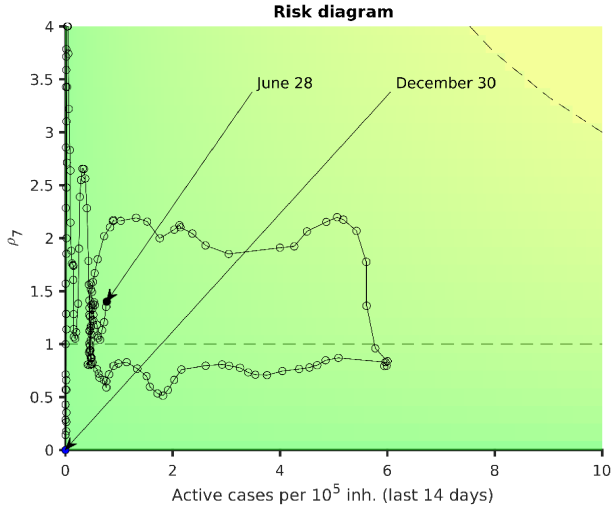


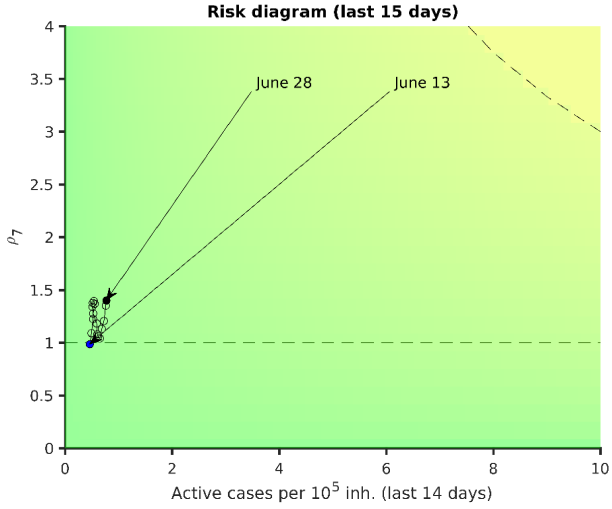




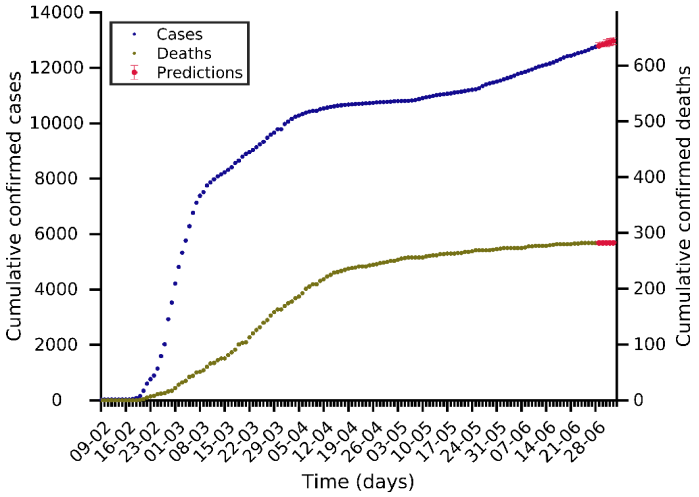


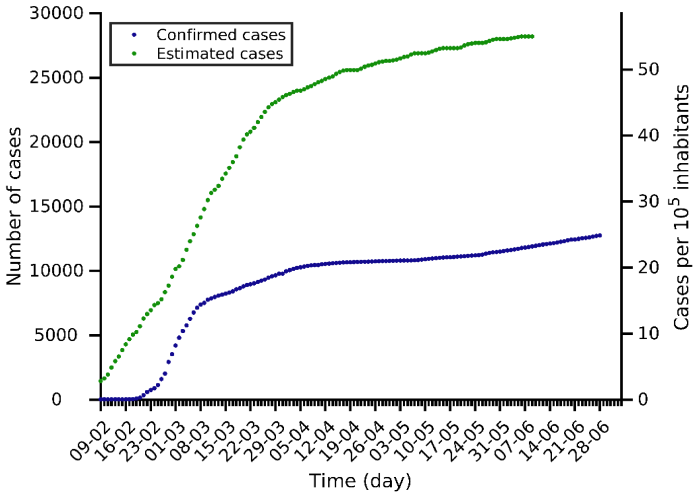


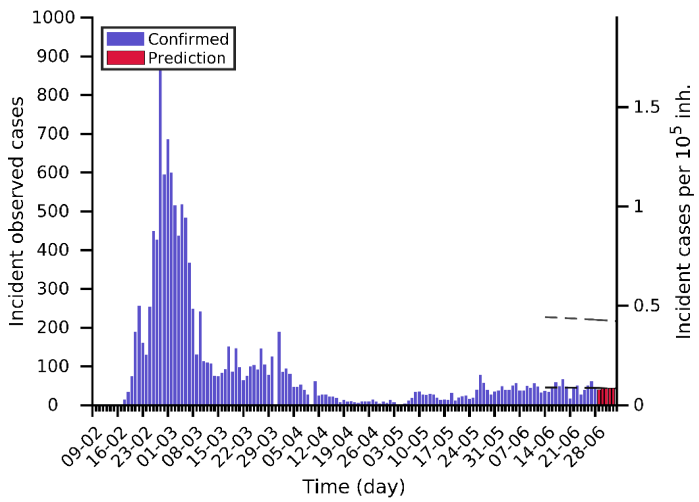


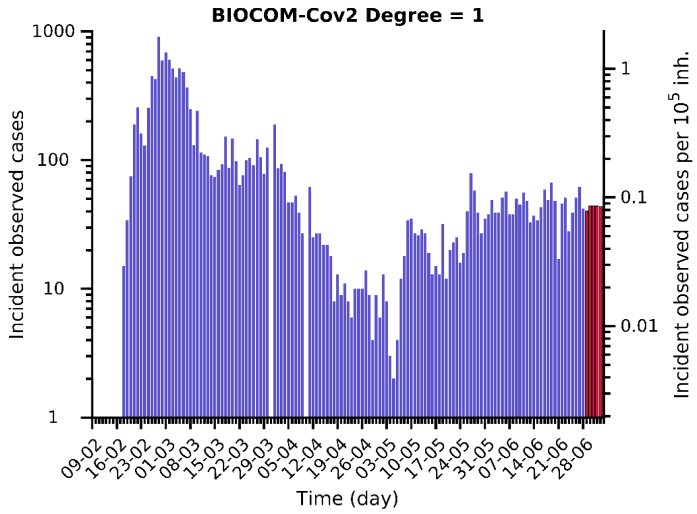


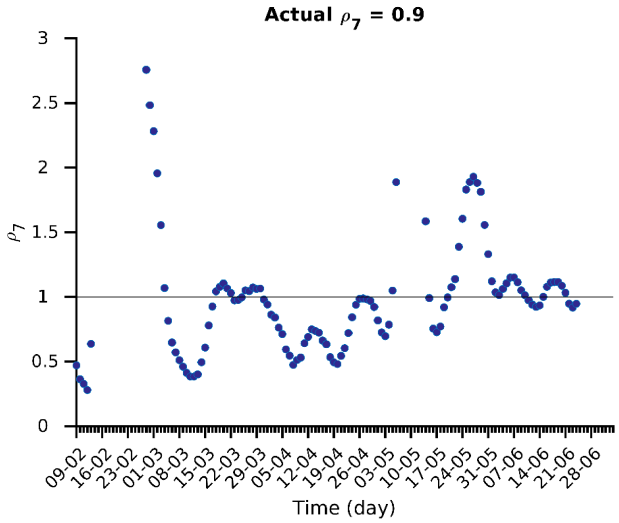
South Korea 28-06-2020. Population: 51.3M. Current cumulative incidence: 25/10^5

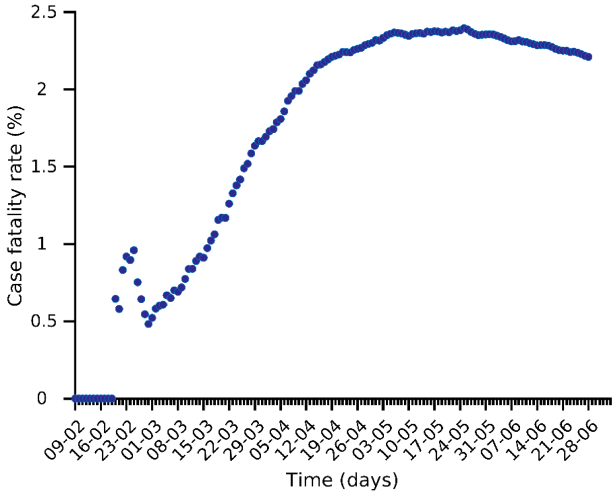


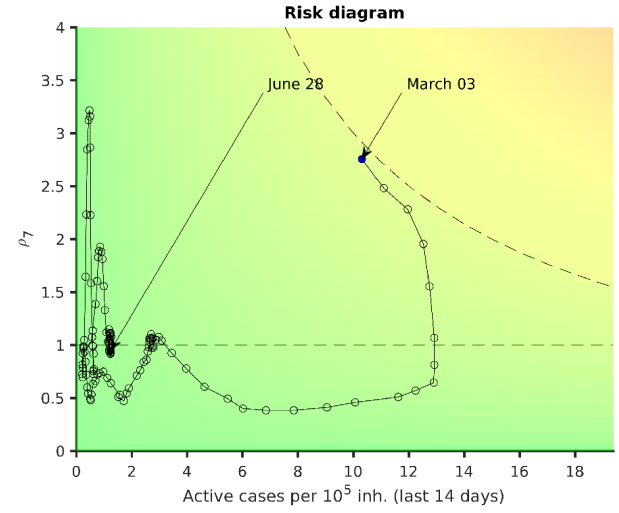


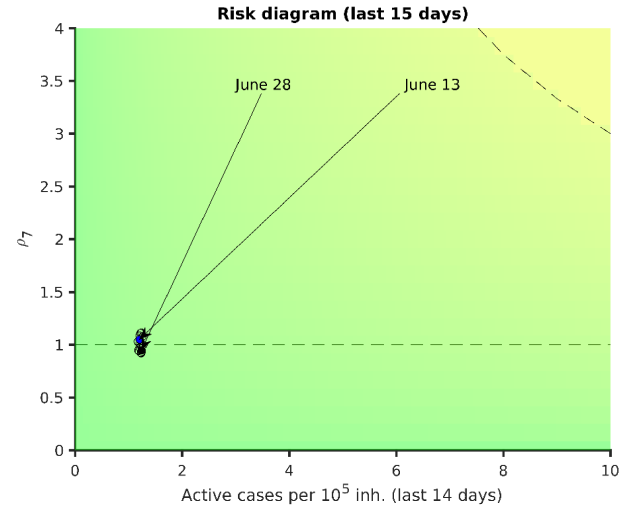




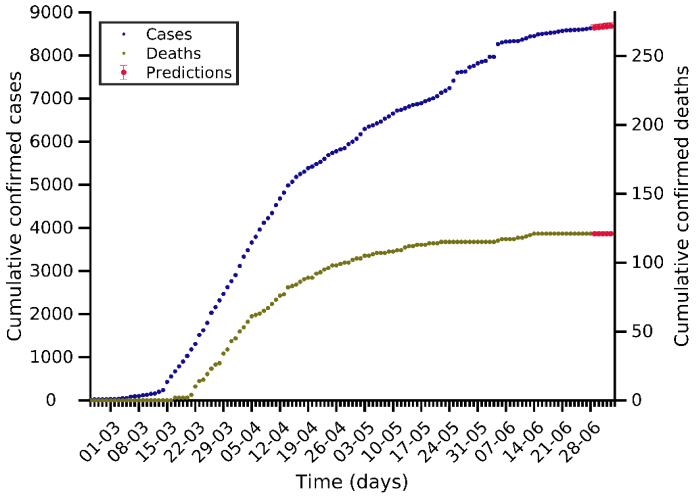


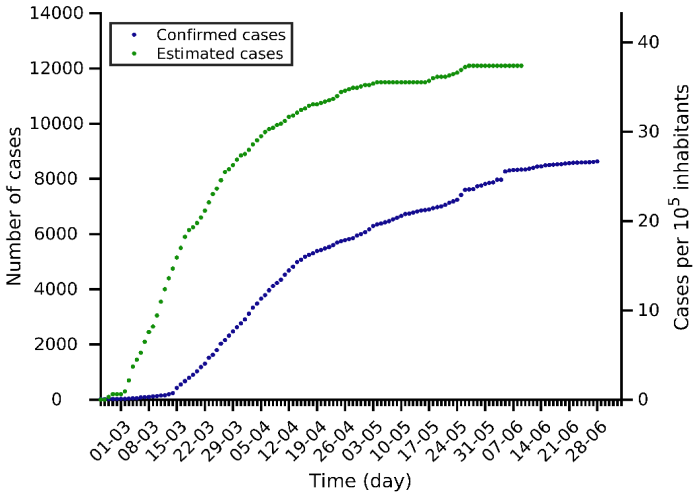


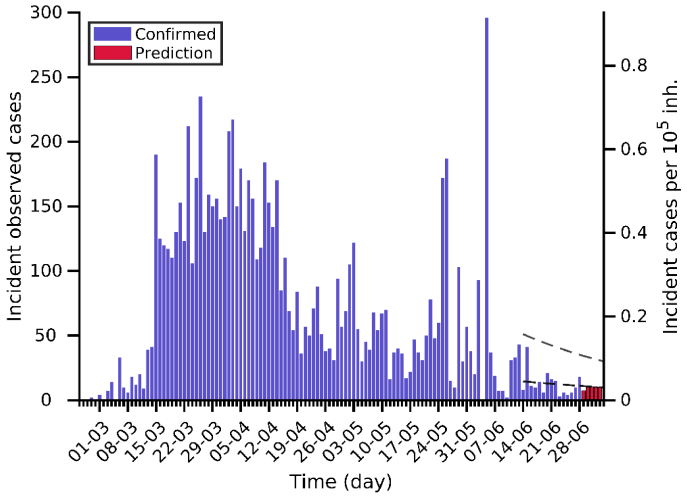


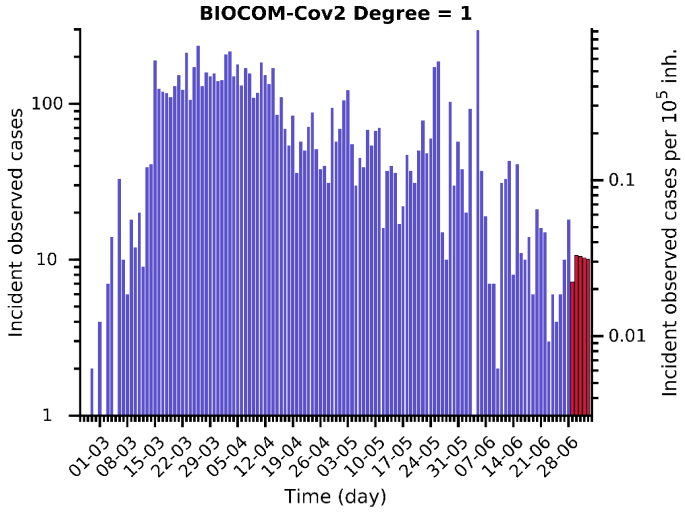


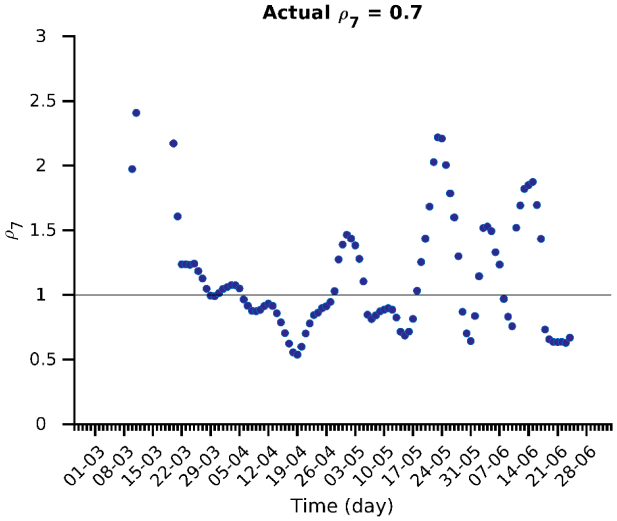
Malaysia 28-06-2020. Population: 32.4M. Current cumulative incidence: 27/10^5

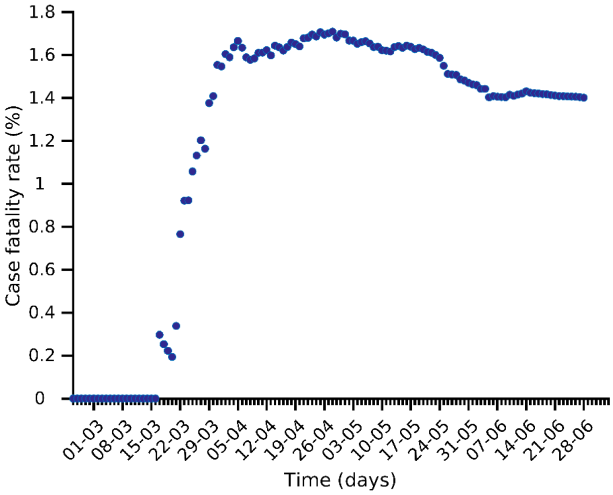


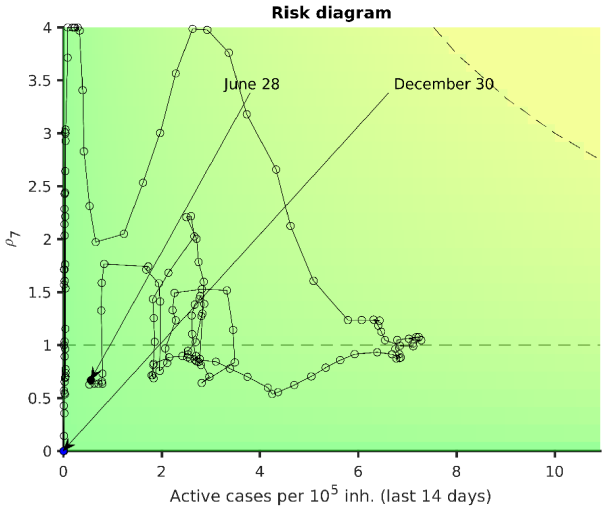


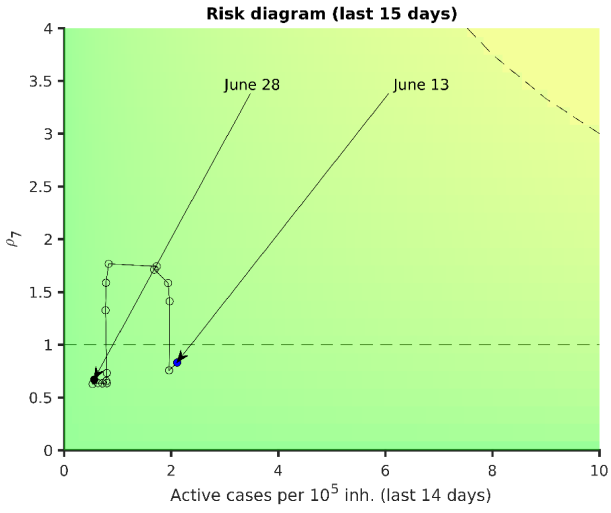




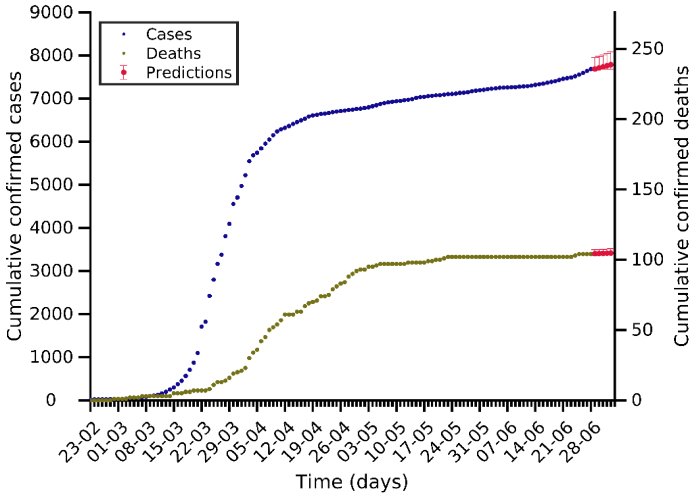


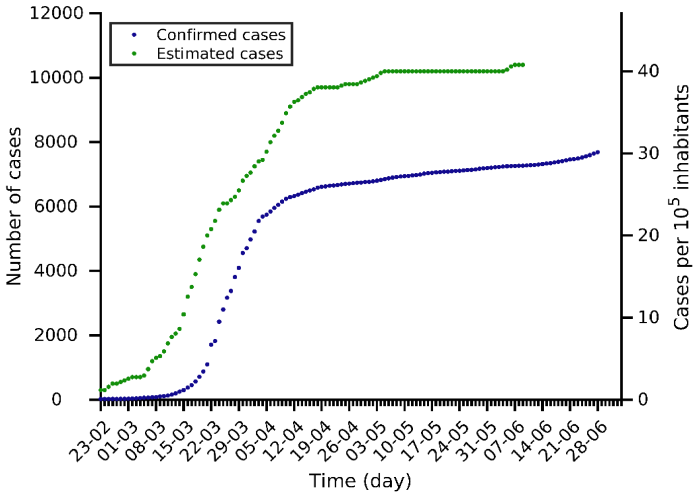


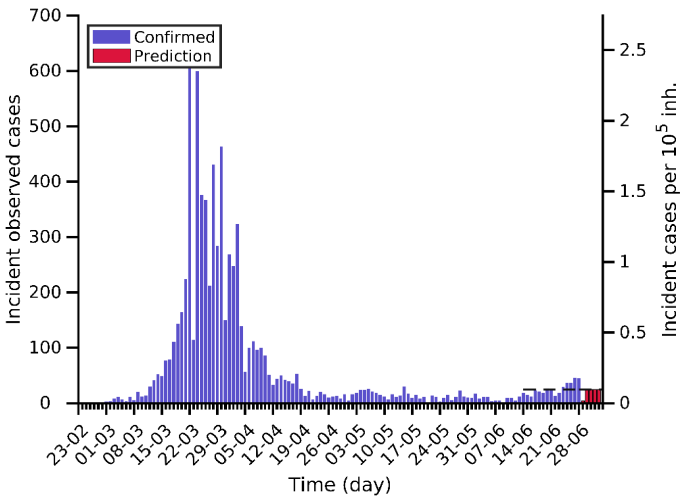


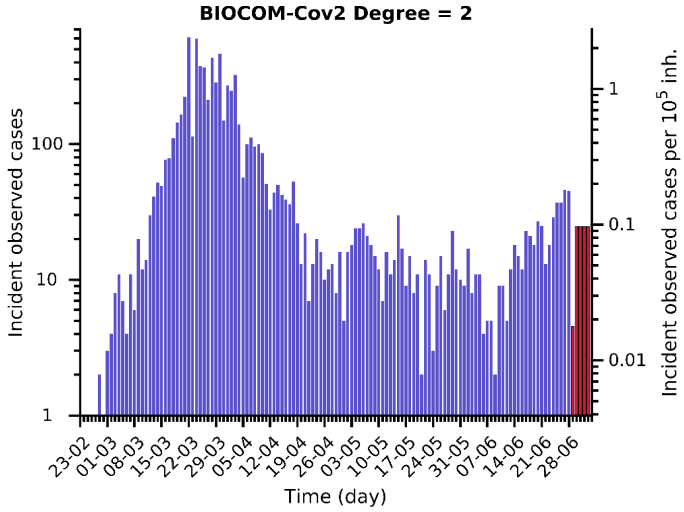


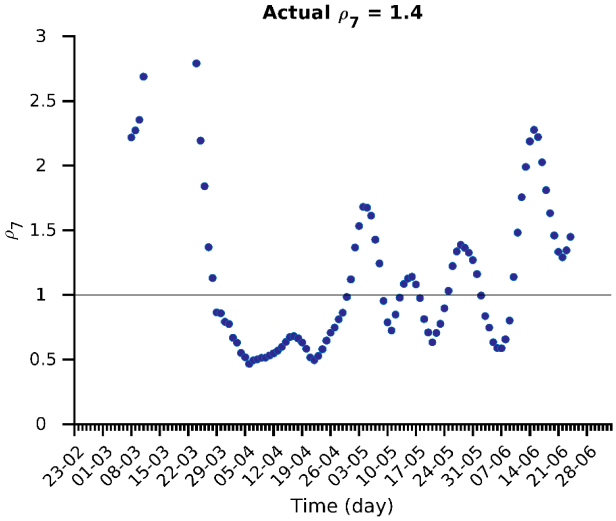
Australia 28-06-2020. Population: 25.5M. Current cumulative incidence: $30/10^5$

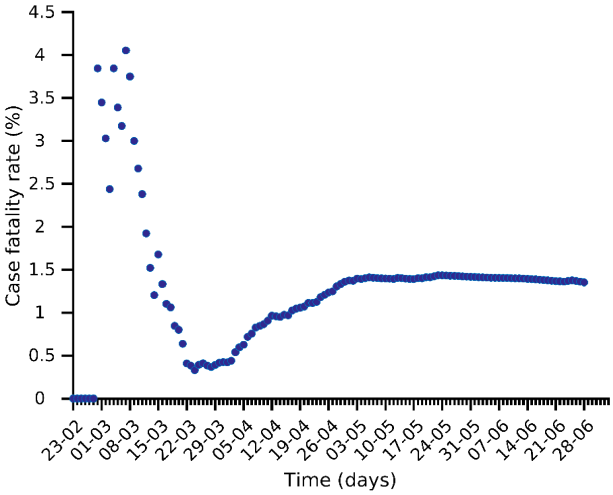


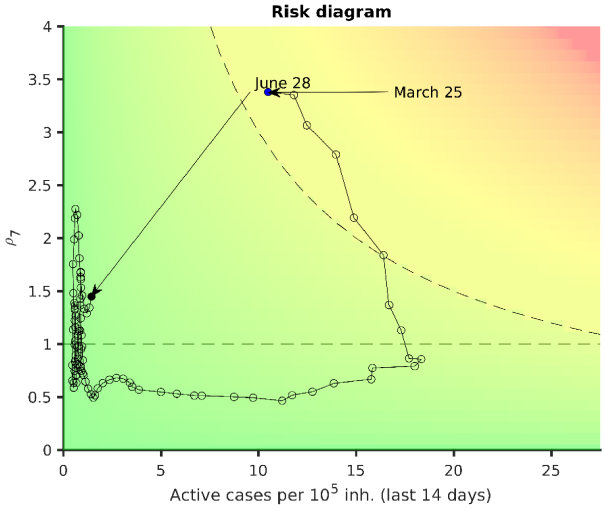


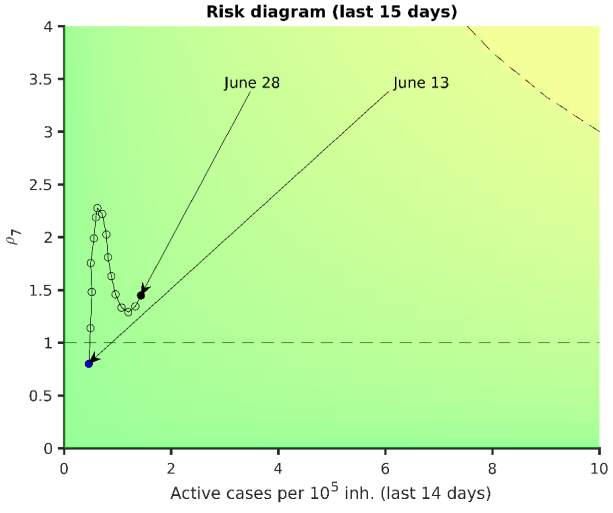




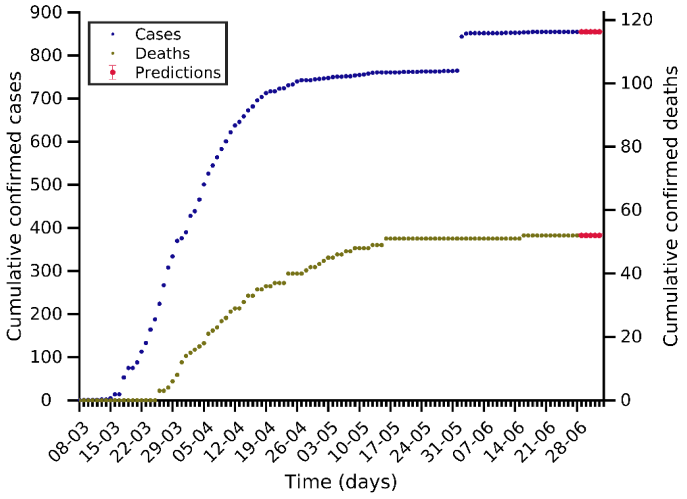


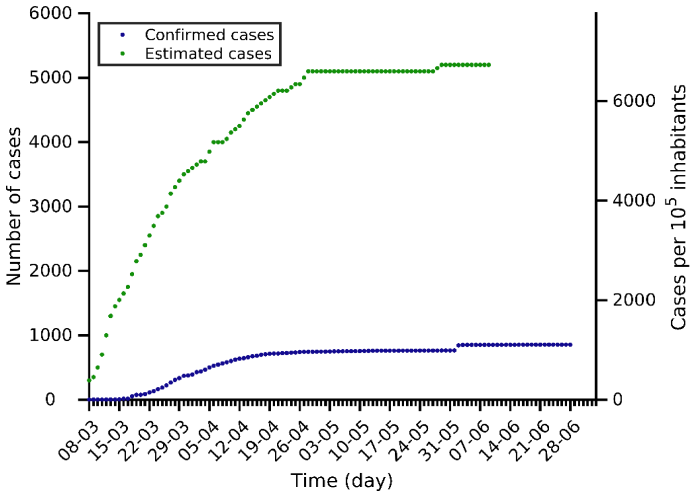


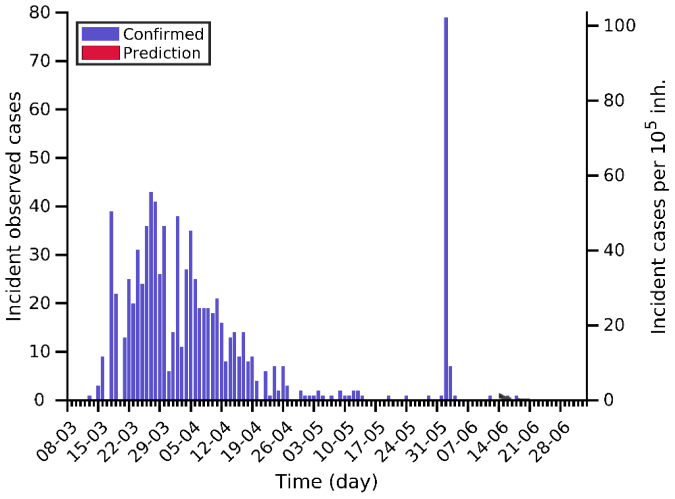


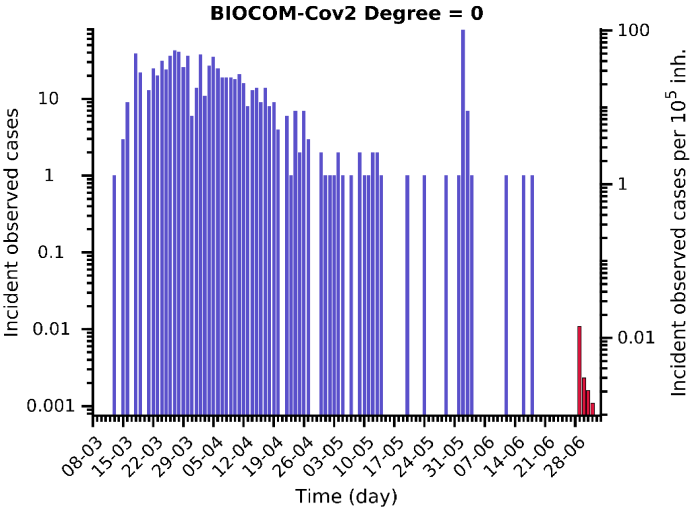


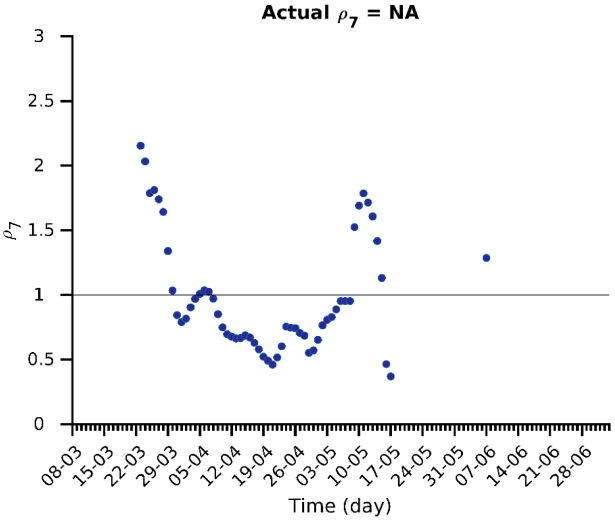
Andorra 28-06-2020. Population: 0.1M. Current cumulative incidence: $1107/10^5$

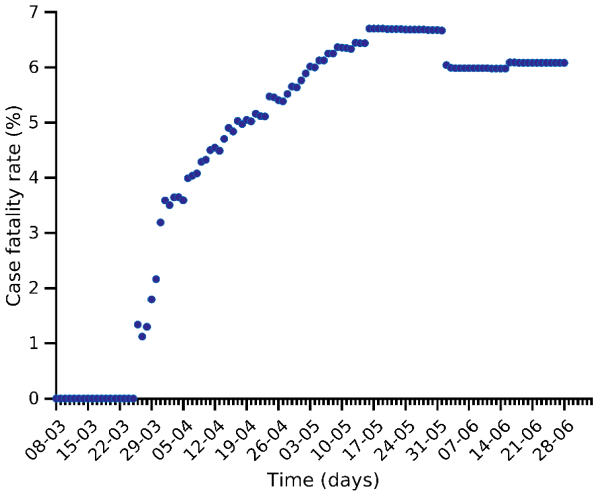


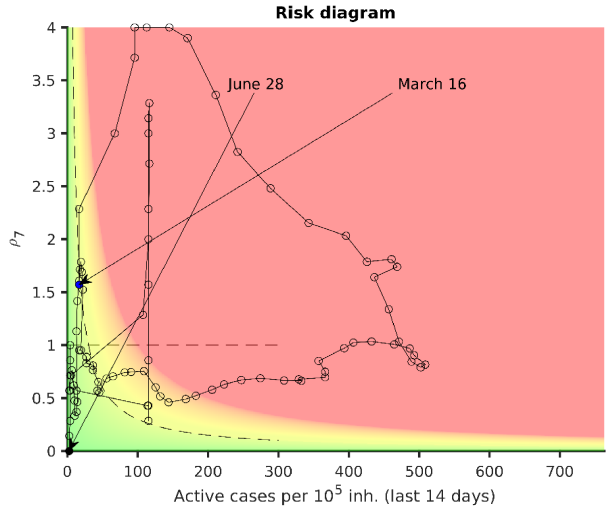


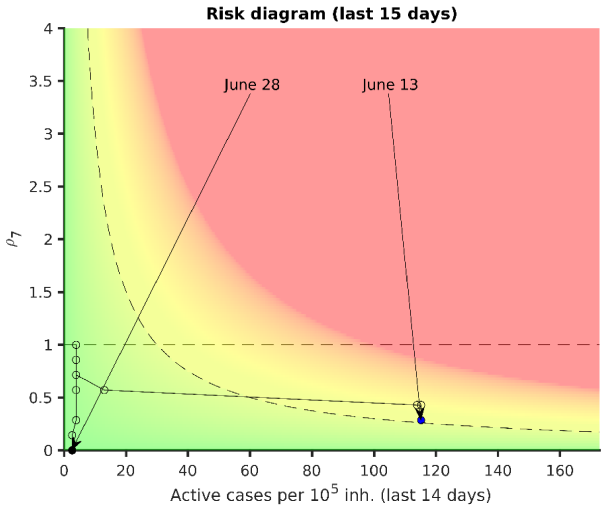










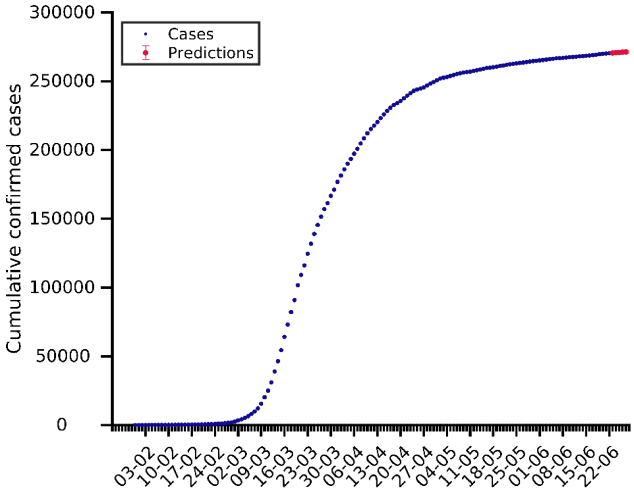


(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

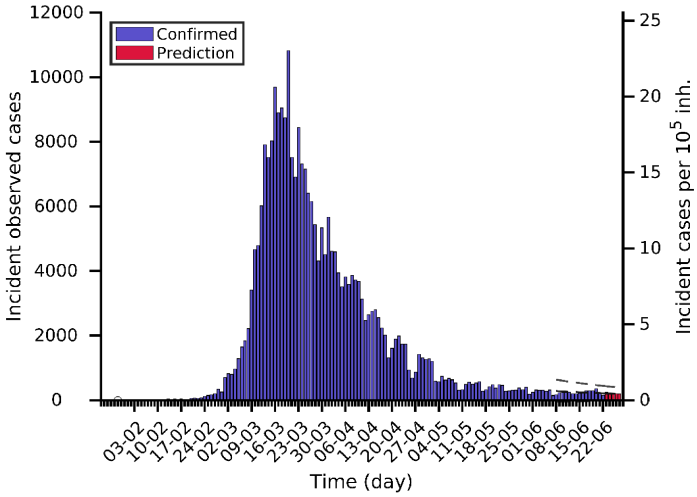
Data updated on 29th June, data series built with the day of the symptoms' onset, reliable until 22th June.

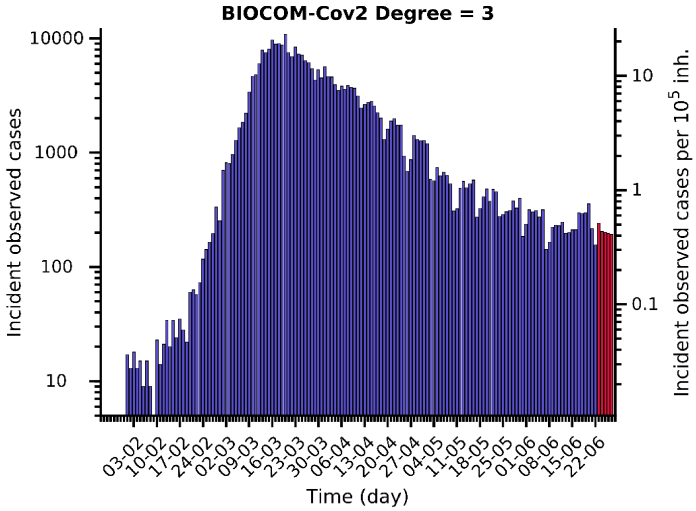
Data obtained from https://github.com/datadista/datasets/tree/master/COVID%2019 and https://covid19.isciii.es/

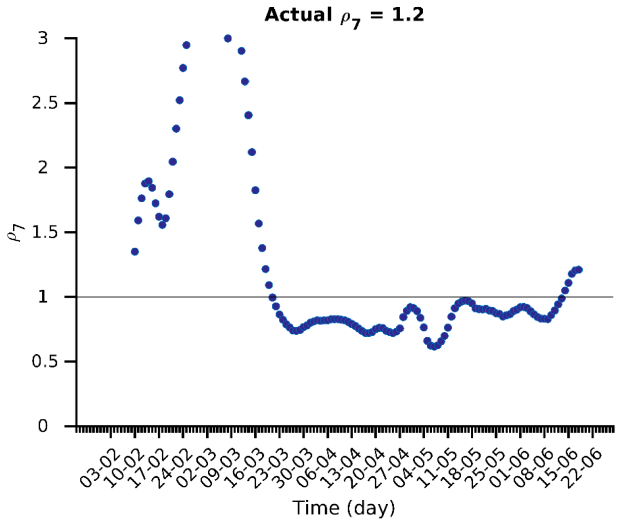
Spain 22-06-2020. Population: 47.0M. Current cumulative incidence: 575/10^5



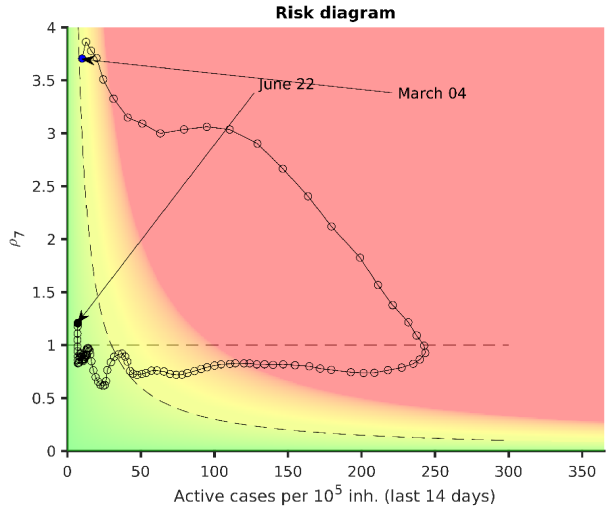
Deaths series currently under revision

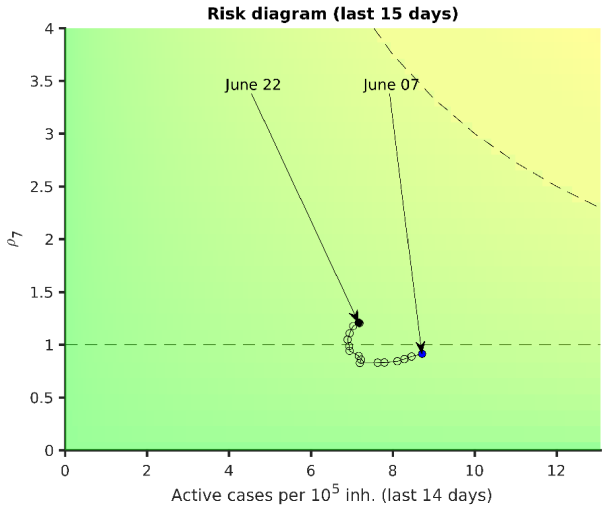




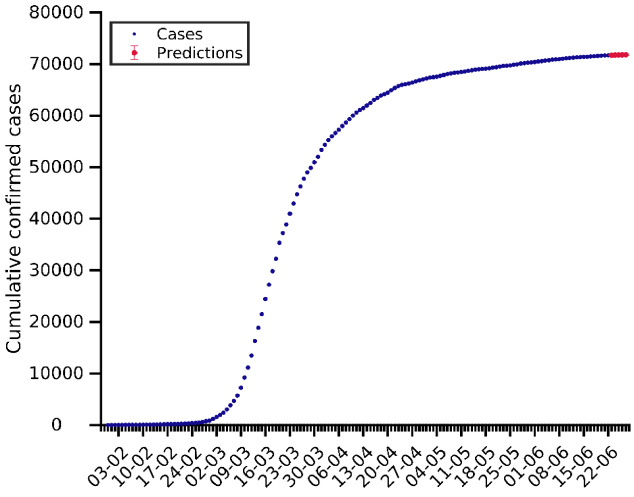


Deaths series currently under revision

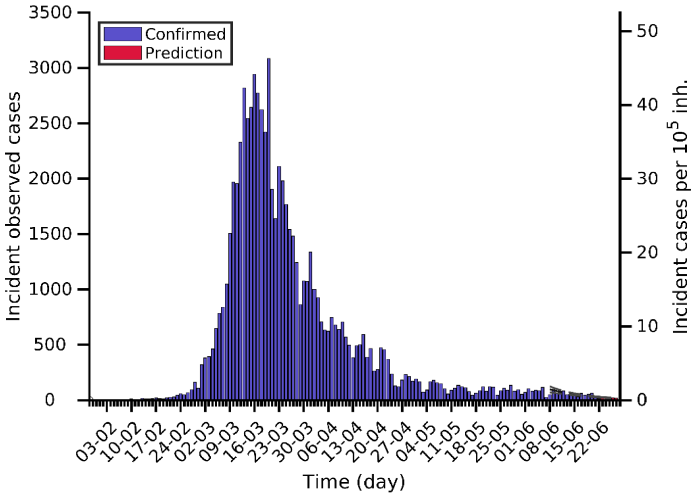


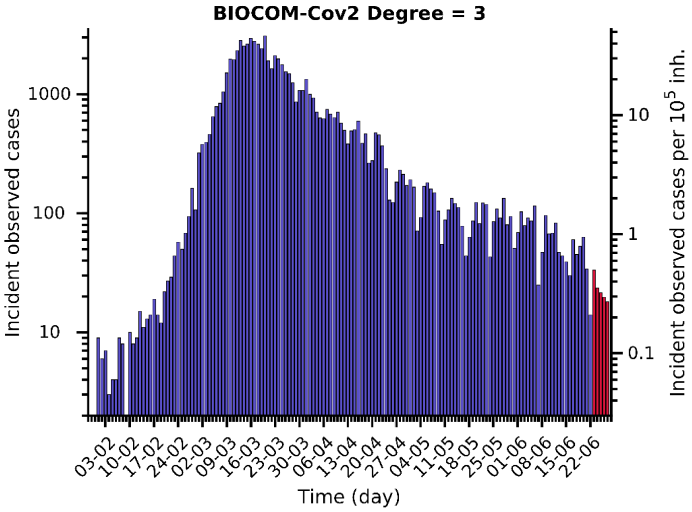


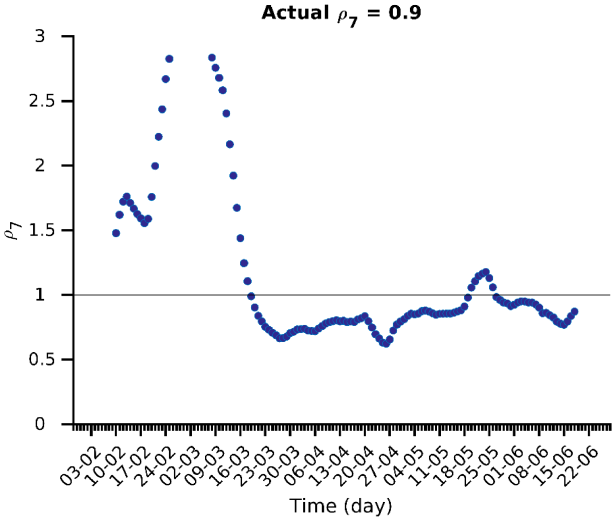
Madrid 22-06-2020. Population: 6.7M. Current cumulative incidence: $1076/10^5$



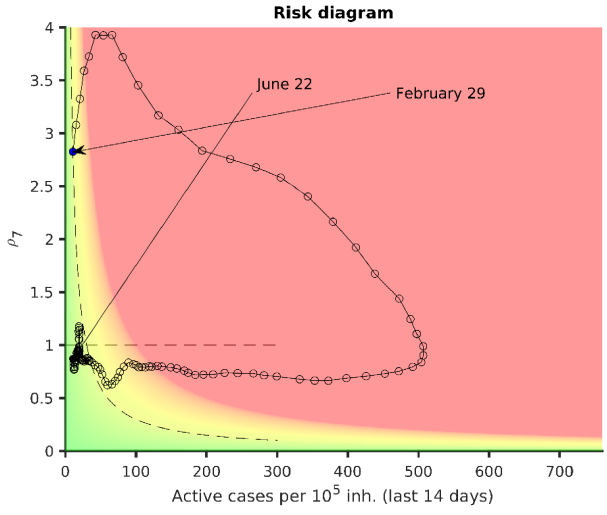
Deaths series currently under revision

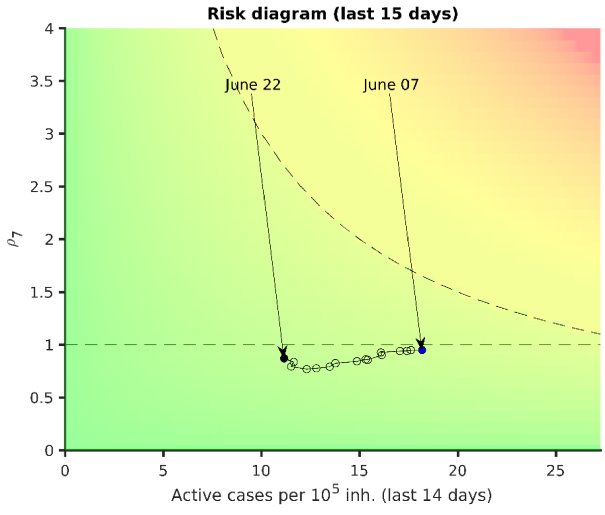




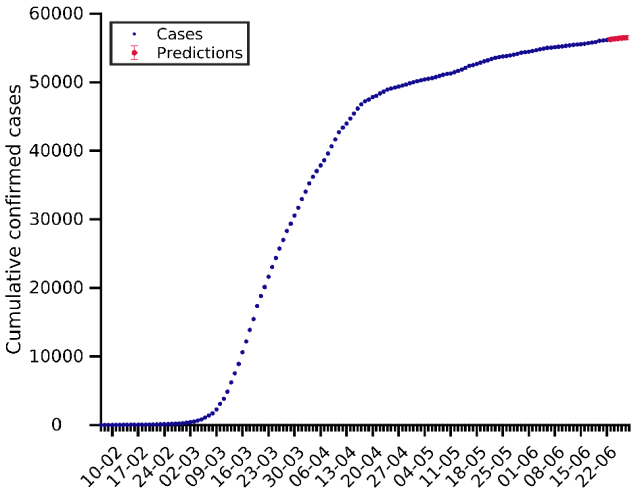


Deaths series currently under revision

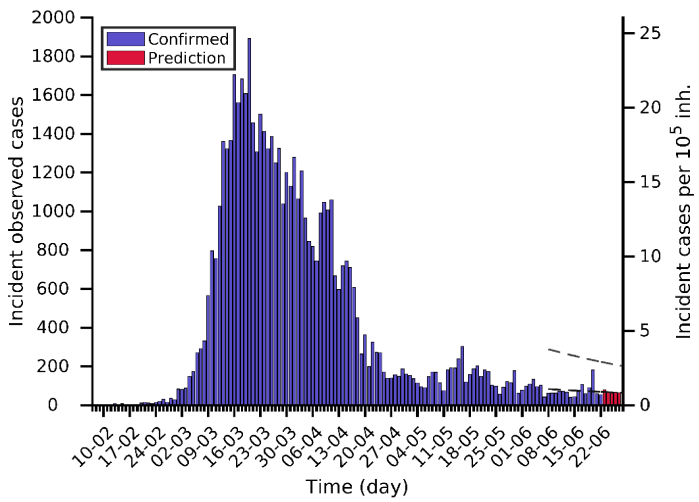


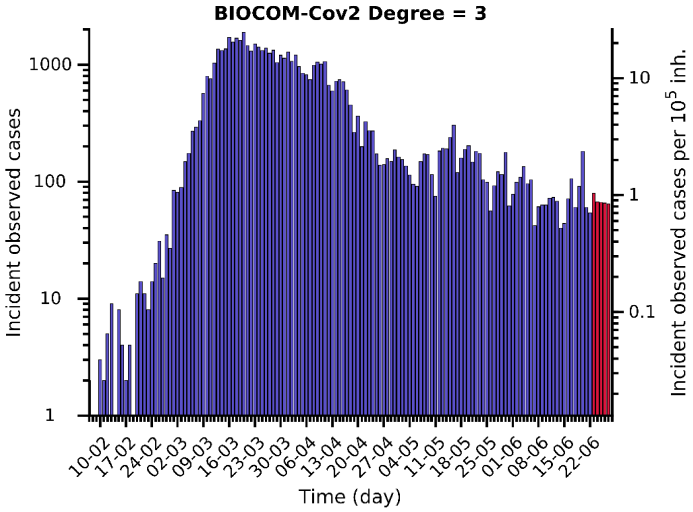


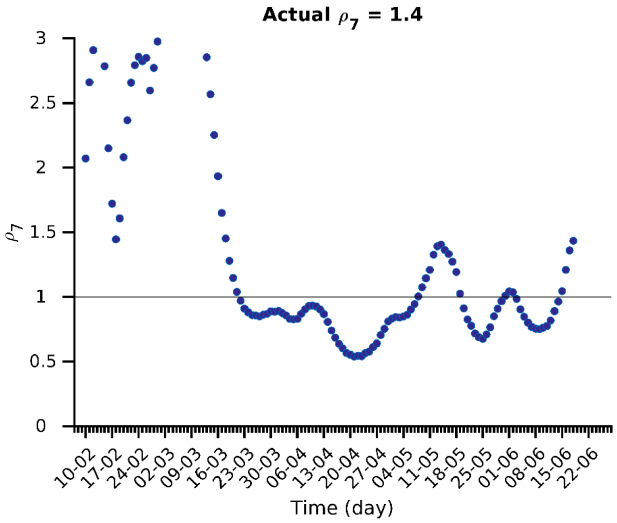
Catalunya 22-06-2020. Population: 7.7M. Current cumulative incidence: 732/10^5



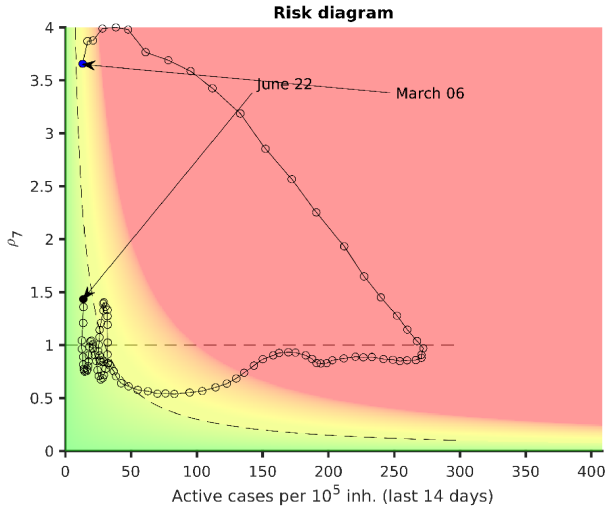
Deaths series currently under revision

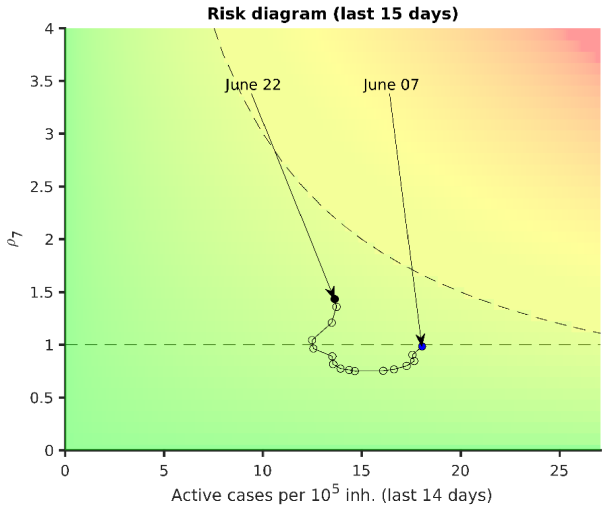




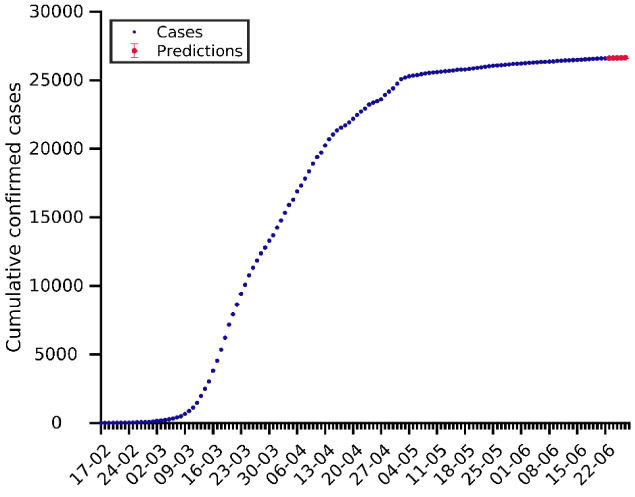


Deaths series currently under revision

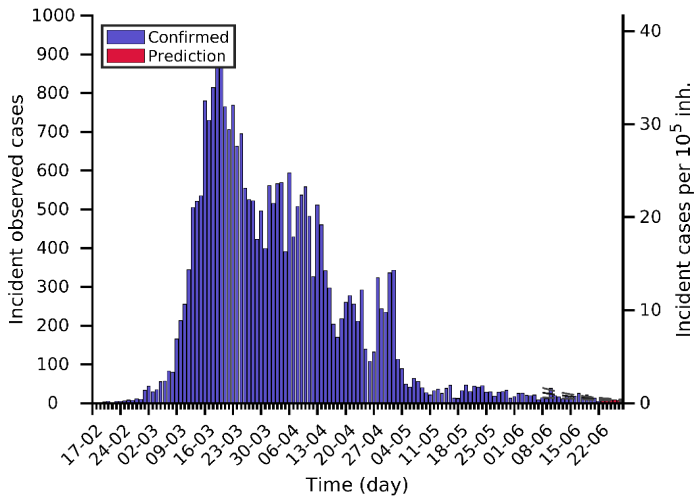


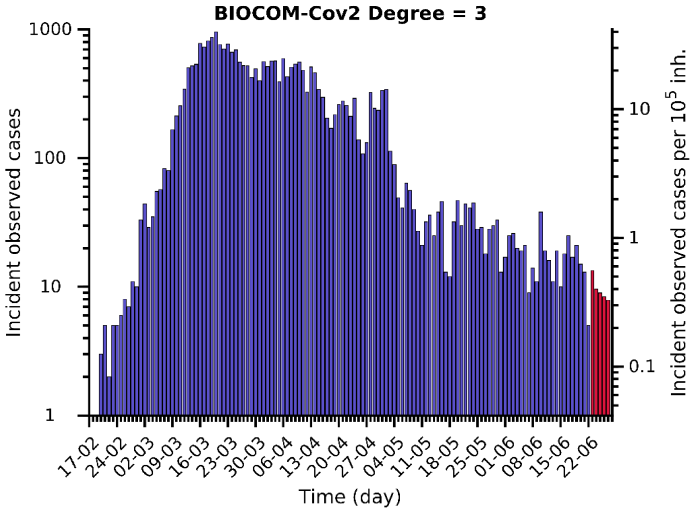


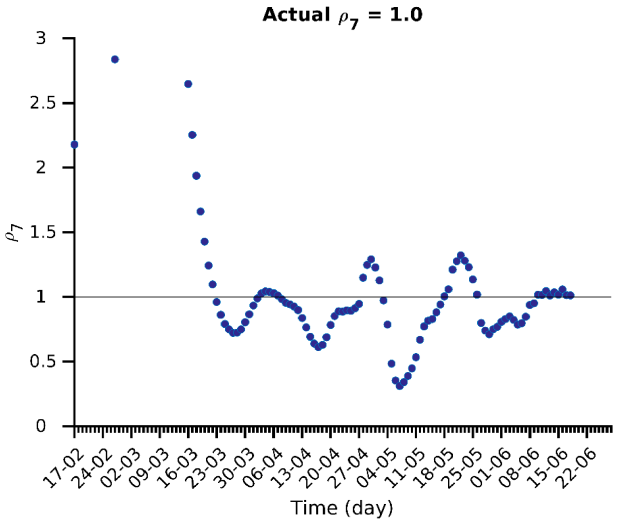
Castilla Leon 22-06-2020. Population: 2.4M. Current cumulative incidence: 1108/10



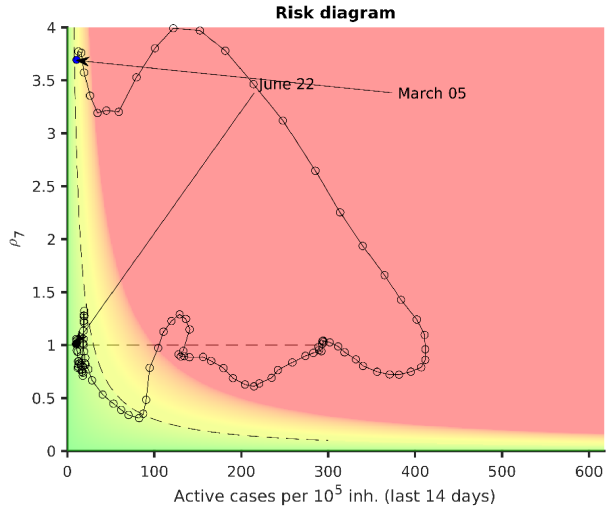
Deaths series currently under revision

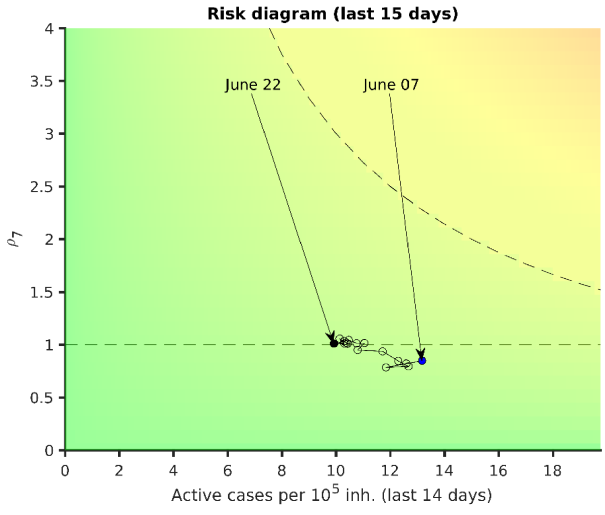




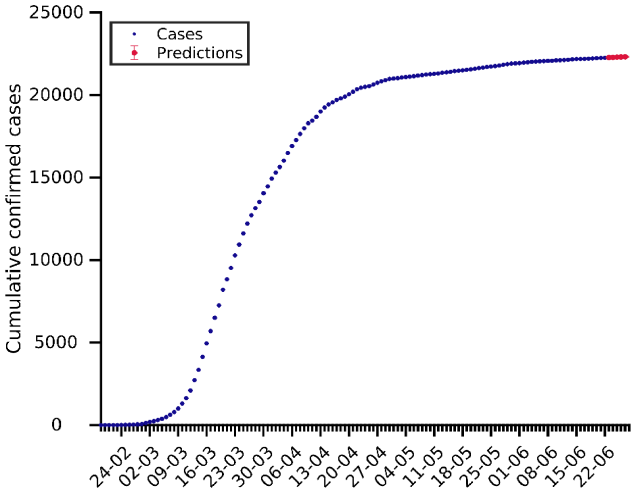


Deaths series currently under revision

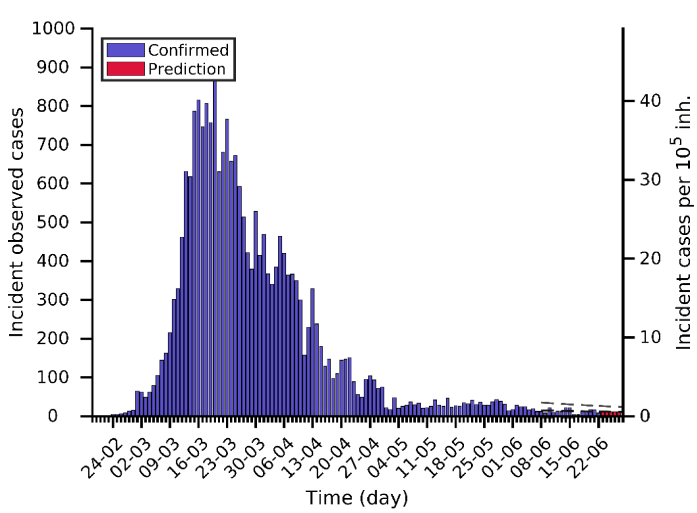


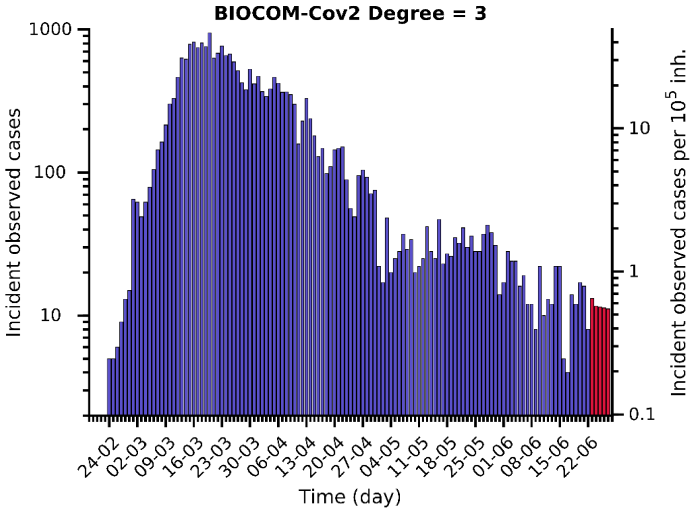


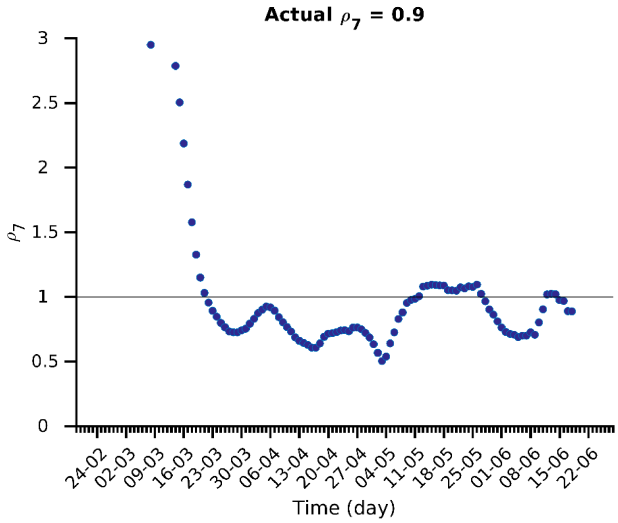
Castilla-La Mancha 22-06-2020. Population: 2.0M. Current cumulative incidence: 10



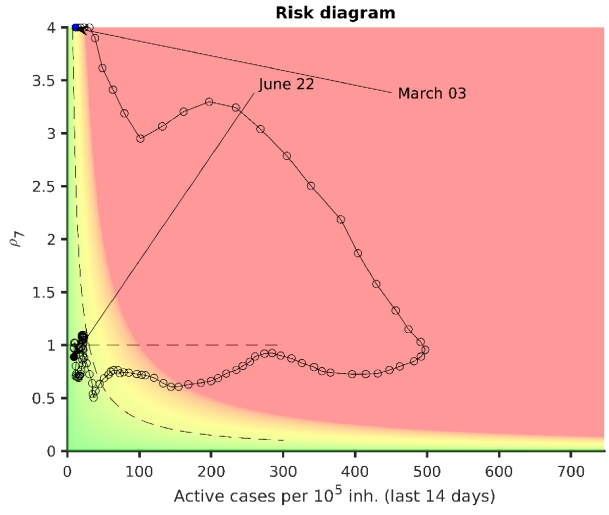
Deaths series currently under revision

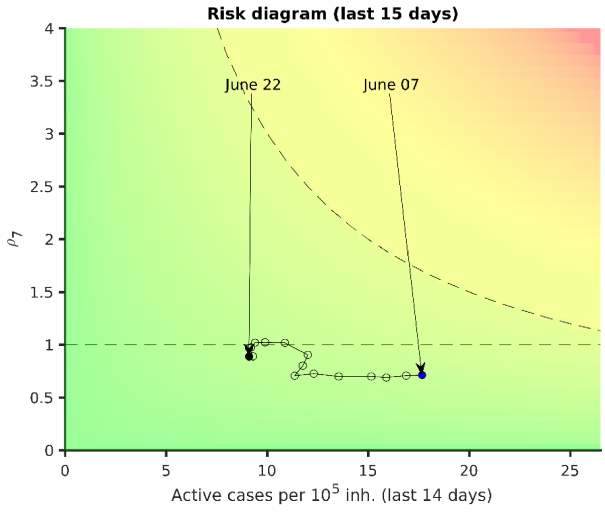




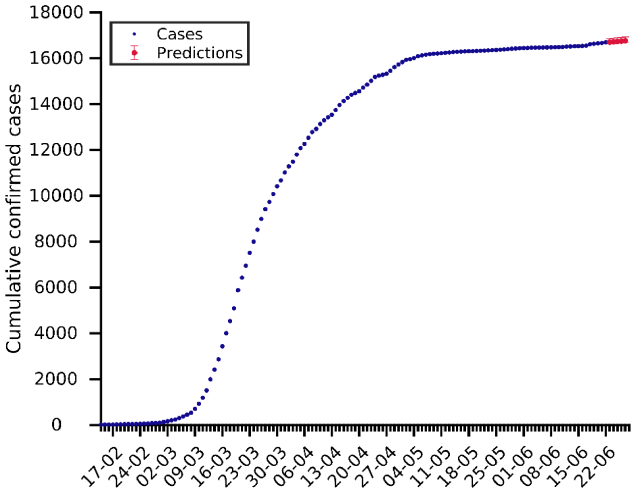


Deaths series currently under revision

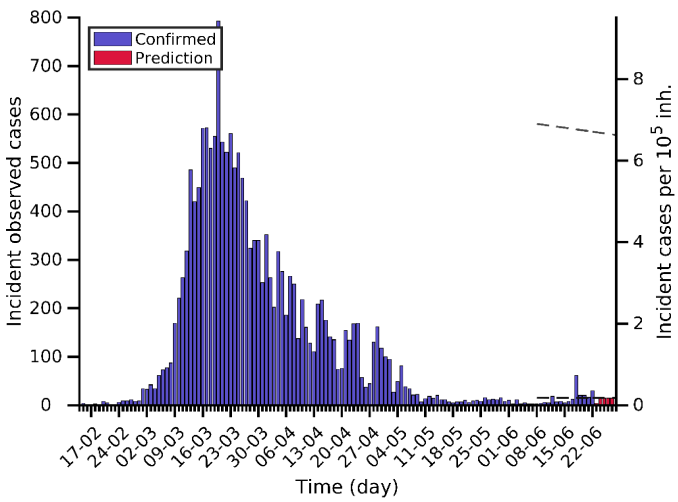


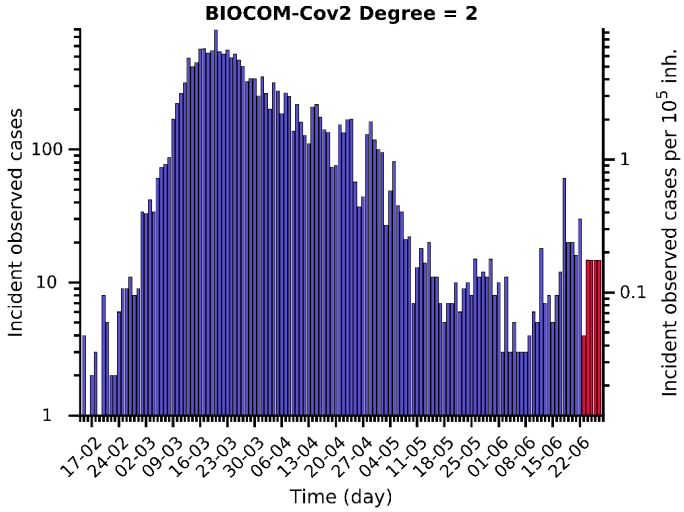


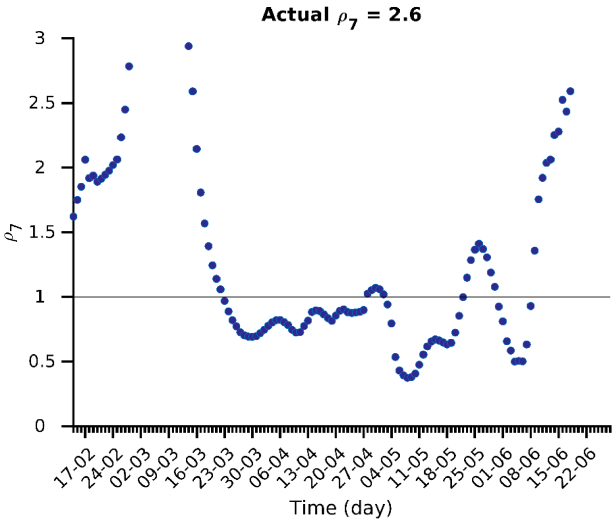
Andalucia 22-06-2020. Population: 8.4M. Current cumulative incidence: 198/10^5



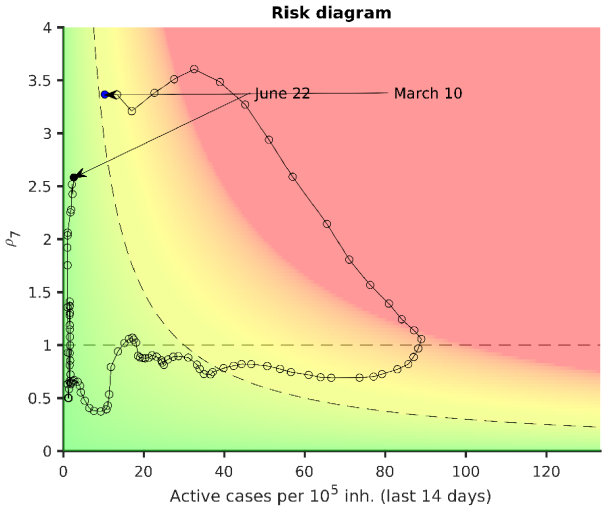
Deaths series currently under revision

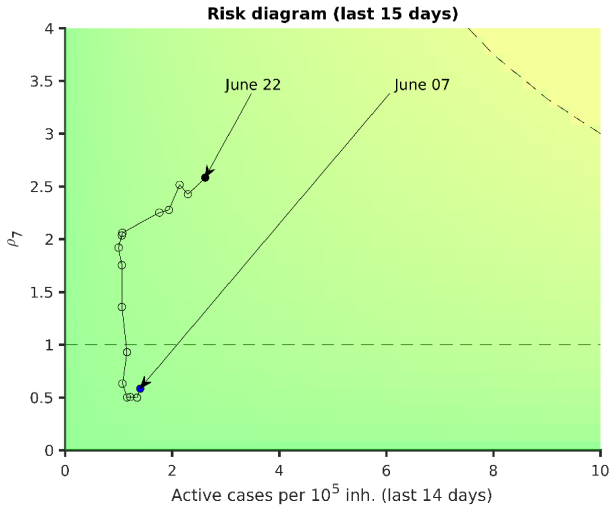




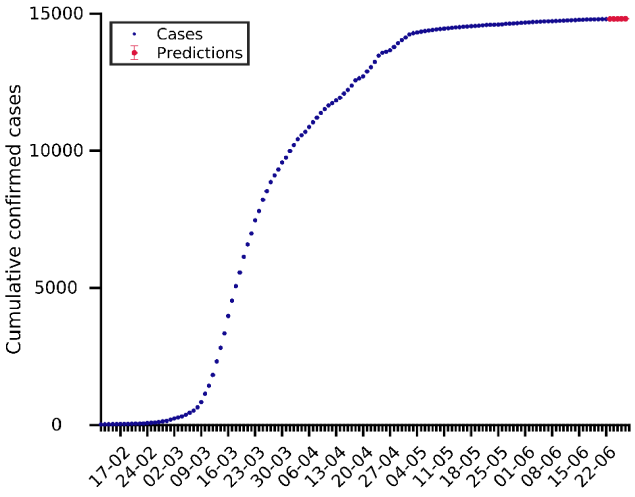


Deaths series currently under revision

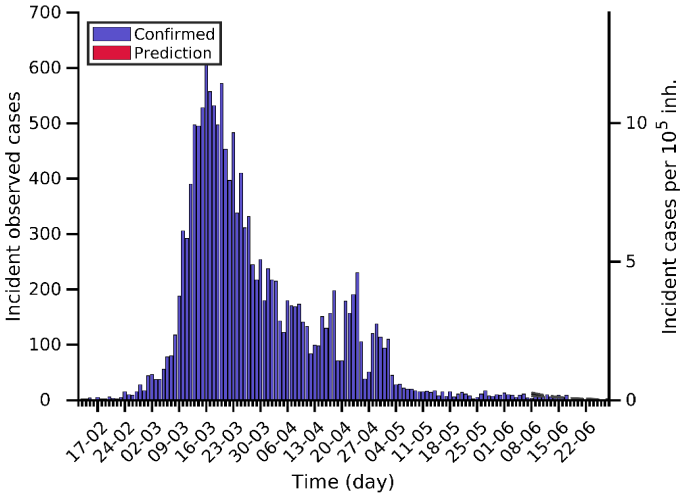


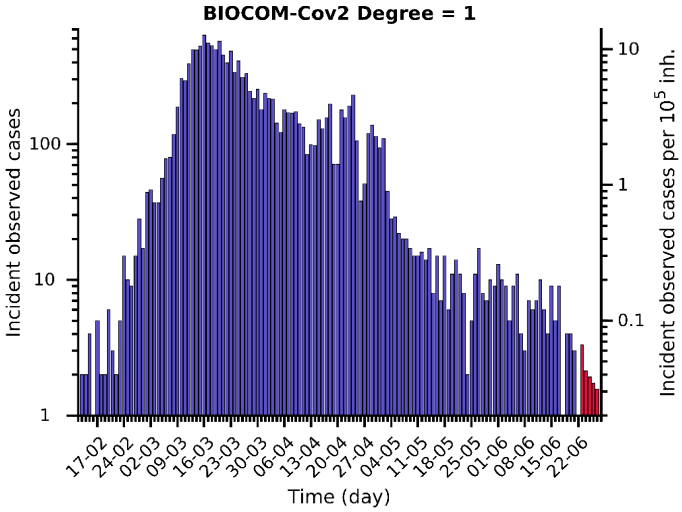


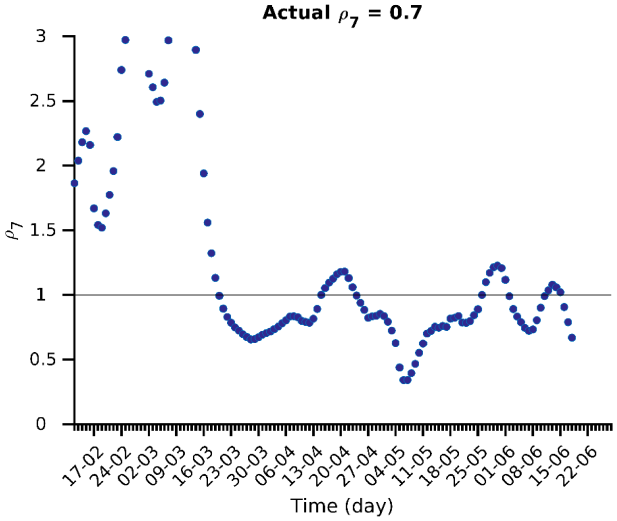
C Valenciana 22-06-2020. Population: 5.0M. Current cumulative incidence: 296/10⁵



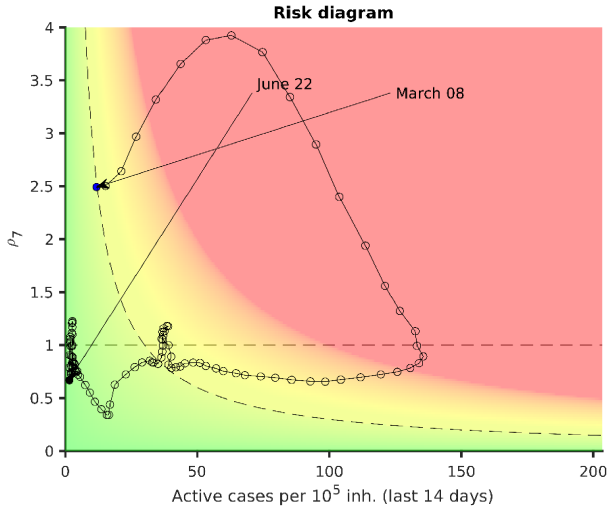
Deaths series currently under revision

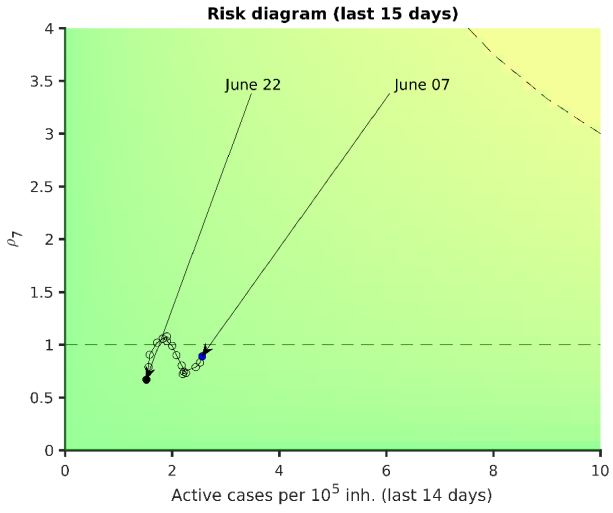




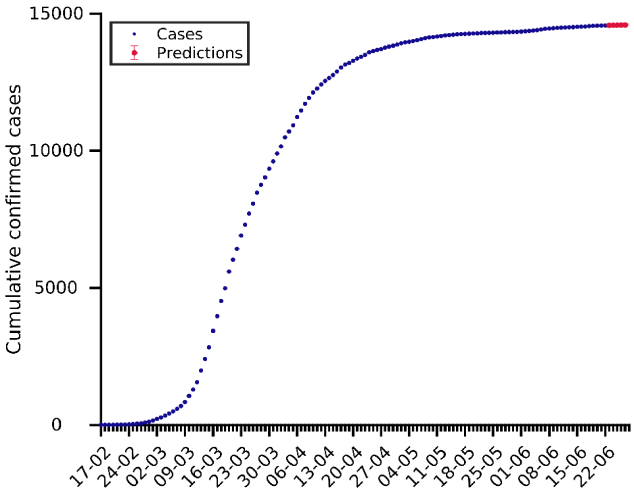


Deaths series currently under revision

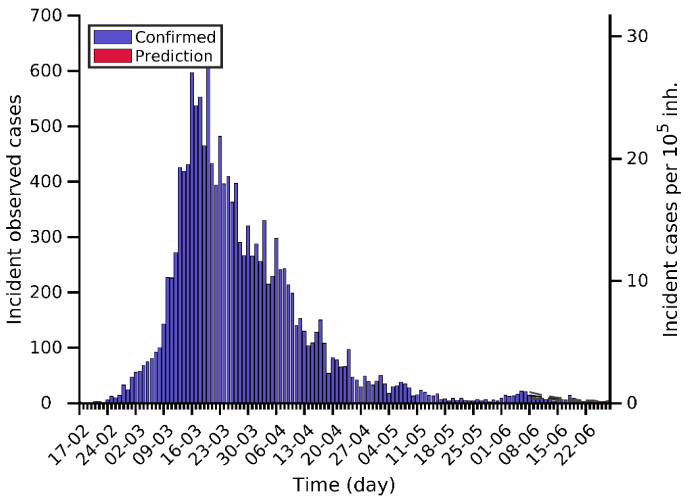


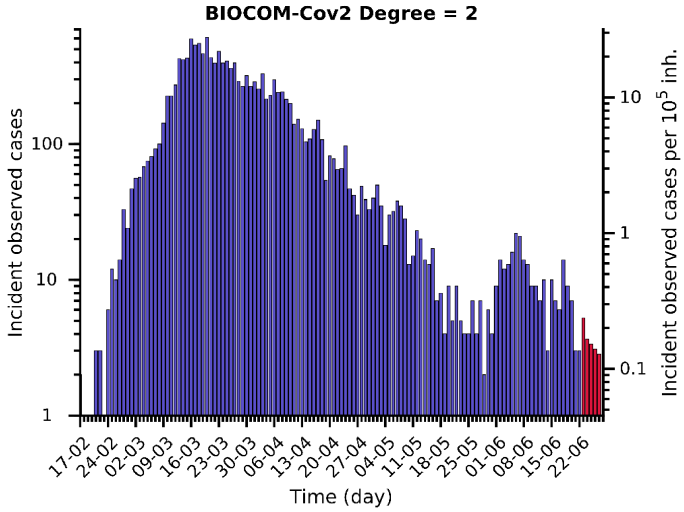


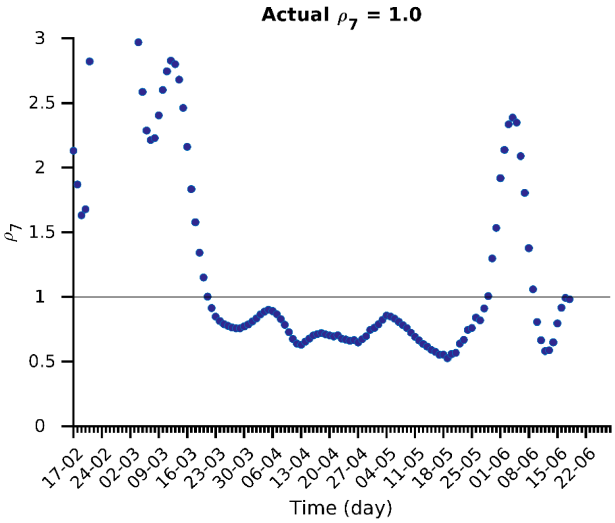
Euskadi 22-06-2020. Population: 2.2M. Current cumulative incidence: 660/10⁵



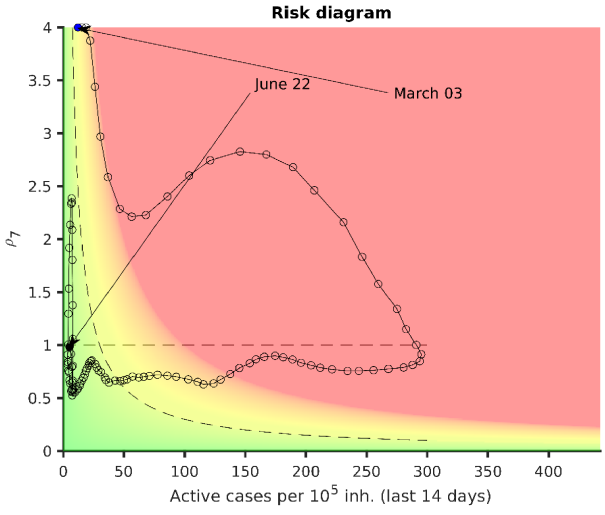
Deaths series currently under revision

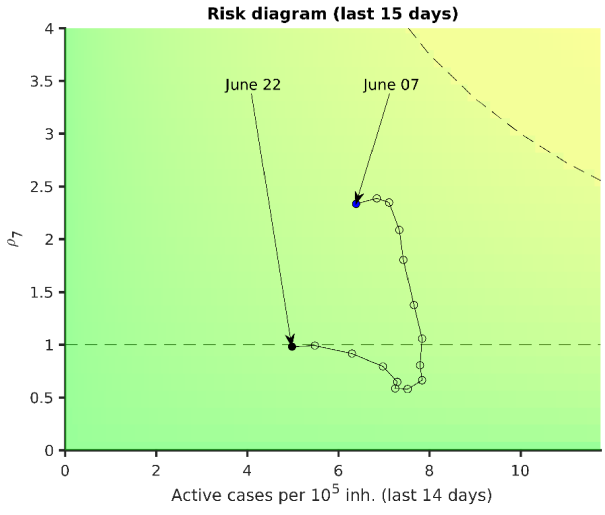




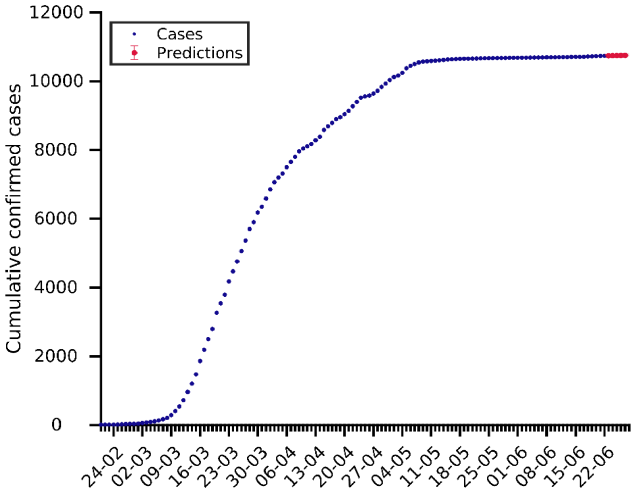


Deaths series currently under revision

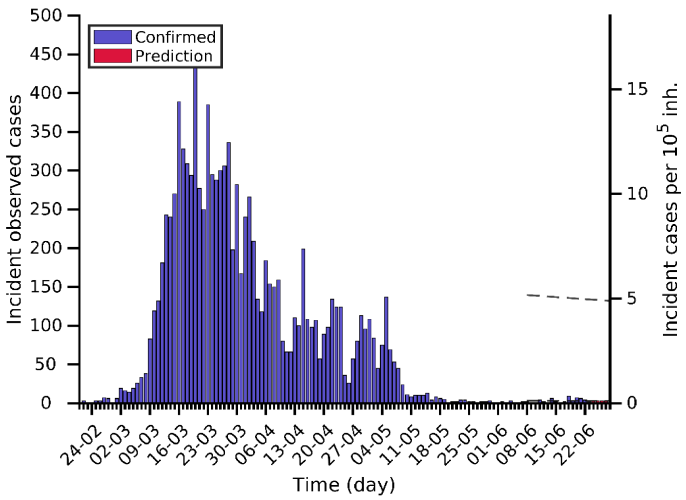


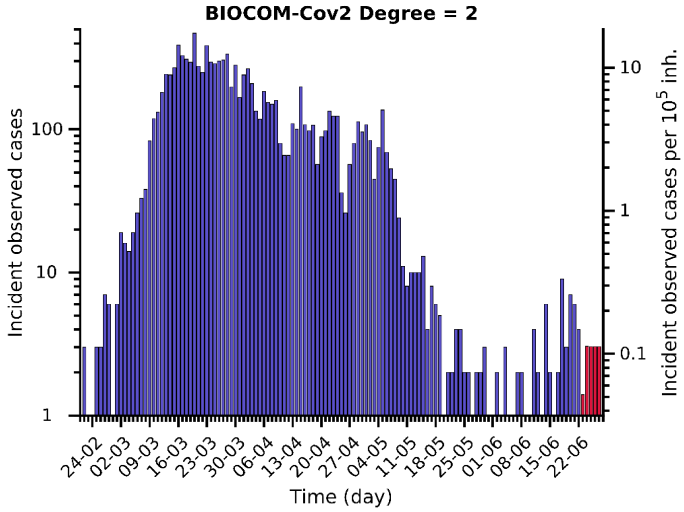


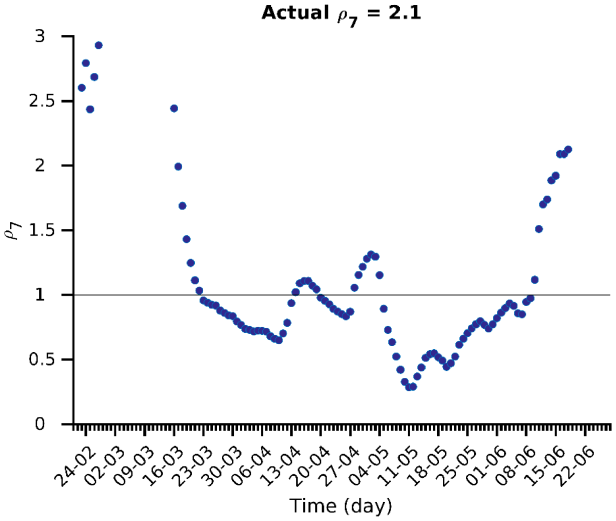
Galicia 22-06-2020. Population: 2.7M. Current cumulative incidence: 398/10^5



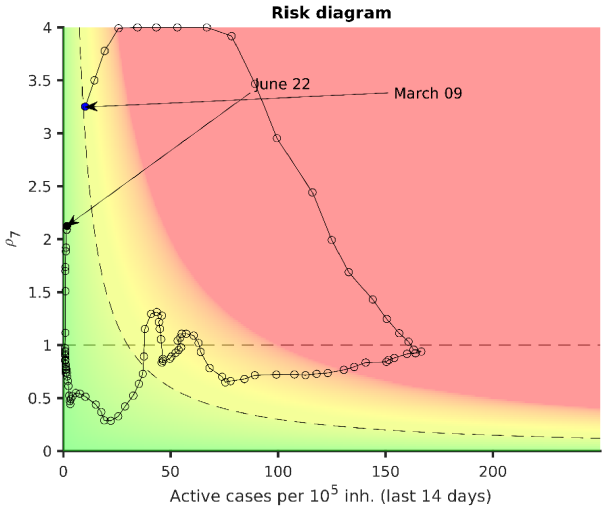
Deaths series currently under revision

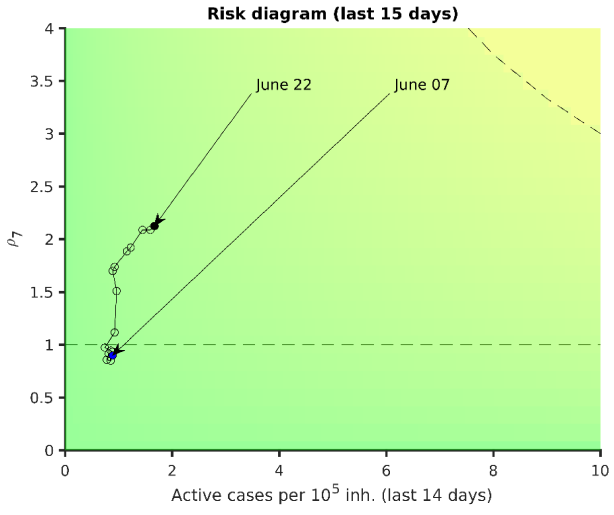




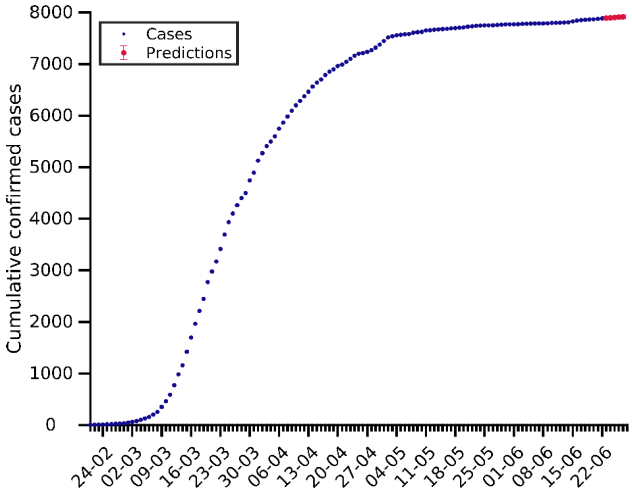


Deaths series currently under revision

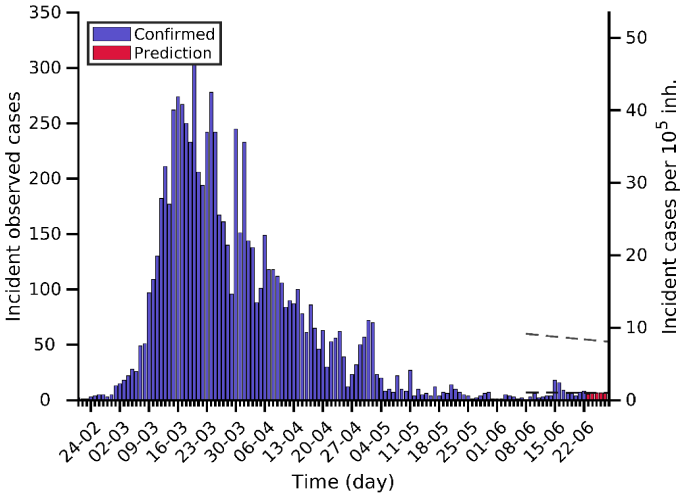


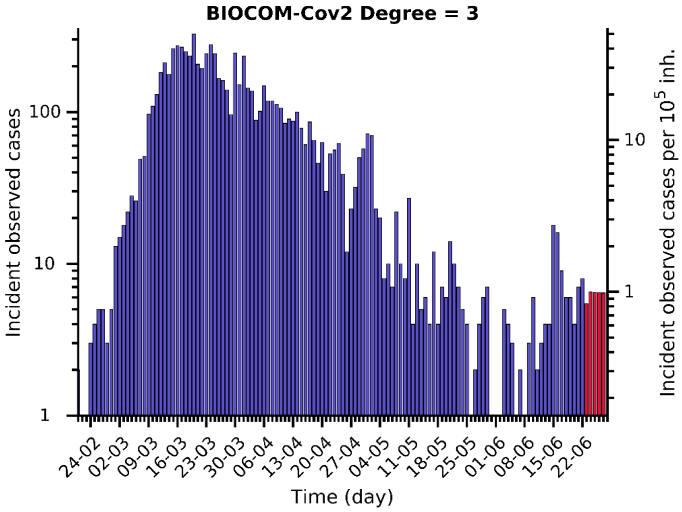


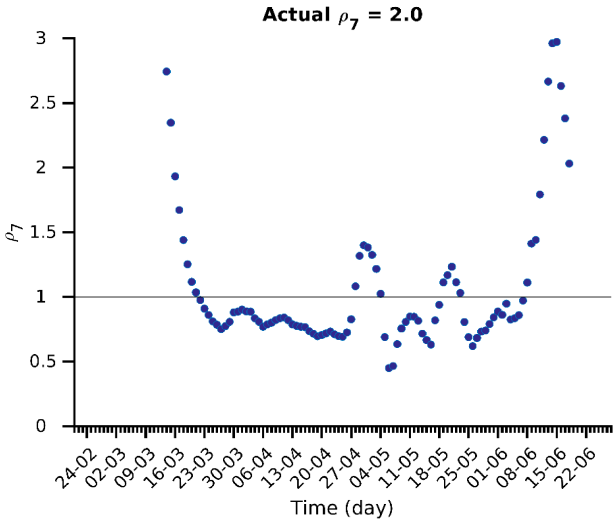
Navarra 22-06-2020. Population: 0.7M. Current cumulative incidence: $1205/10^5$



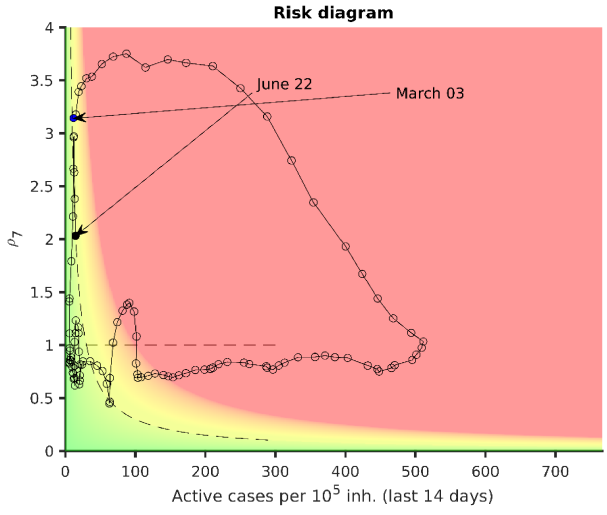
Deaths series currently under revision

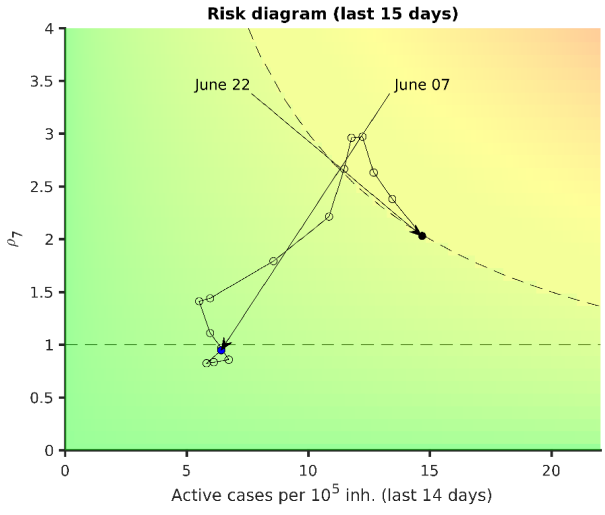




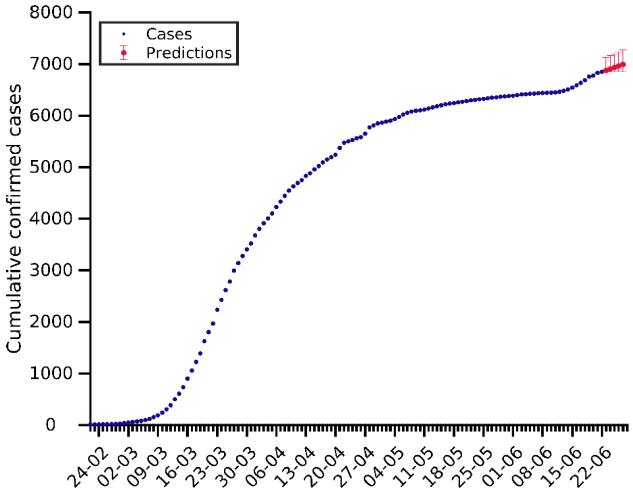


Deaths series currently under revision

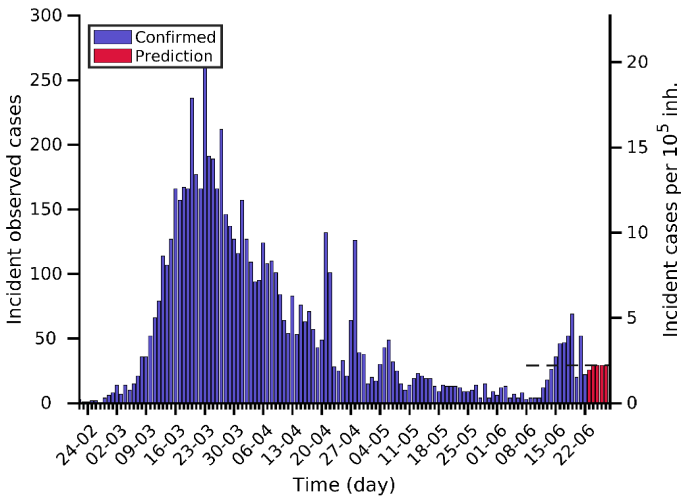


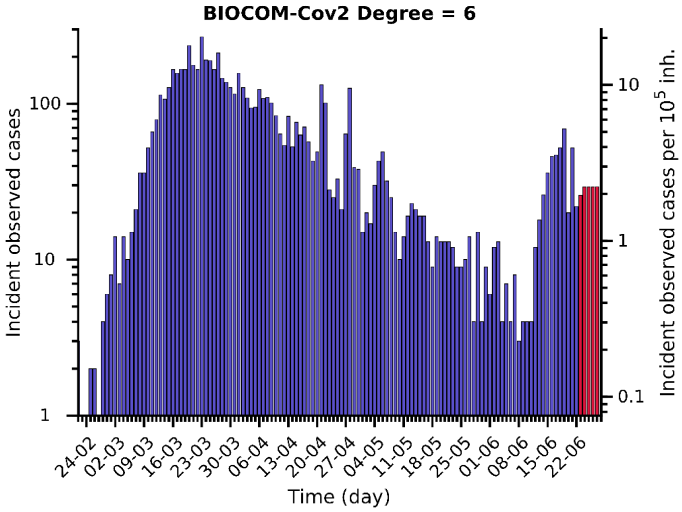


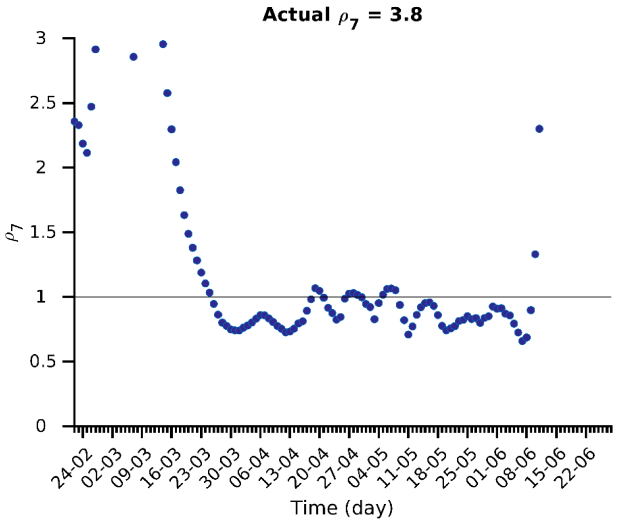
Aragon 22-06-2020. Population: 1.3M. Current cumulative incidence: 519/10^5



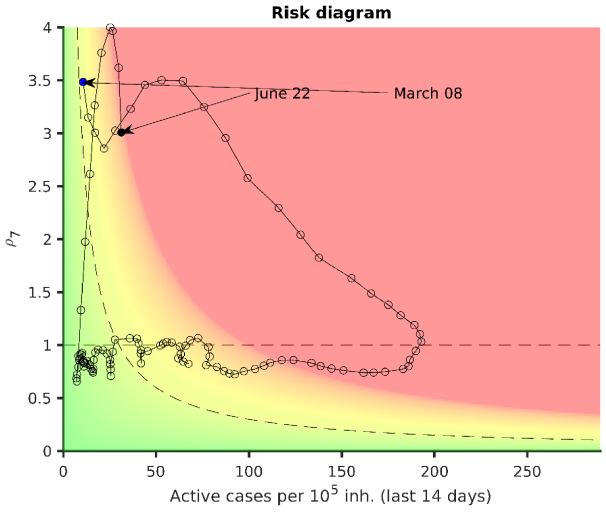
Deaths series currently under revision

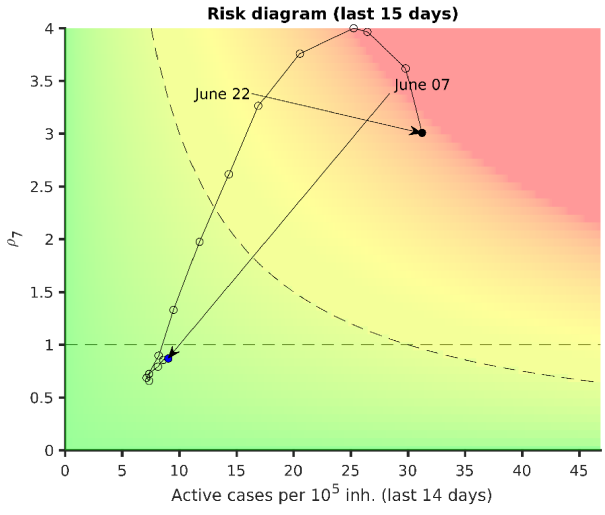




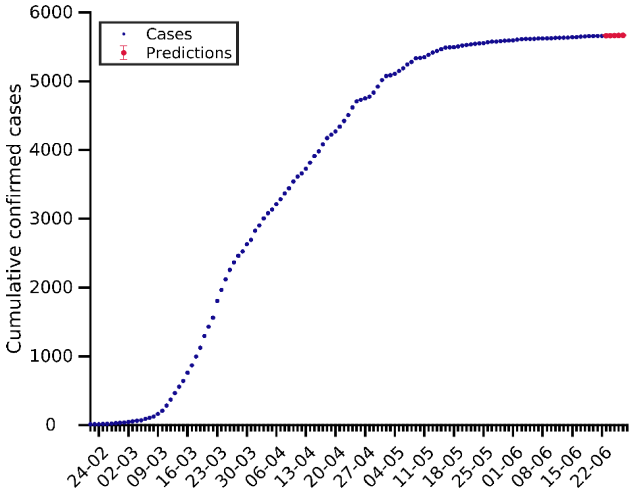


Deaths series currently under revision

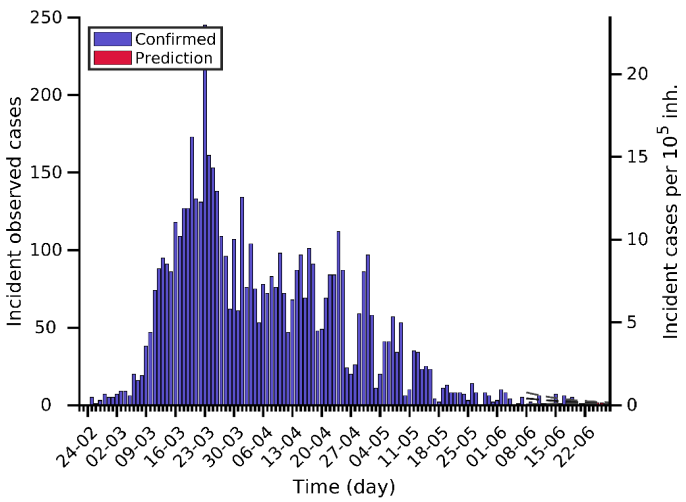


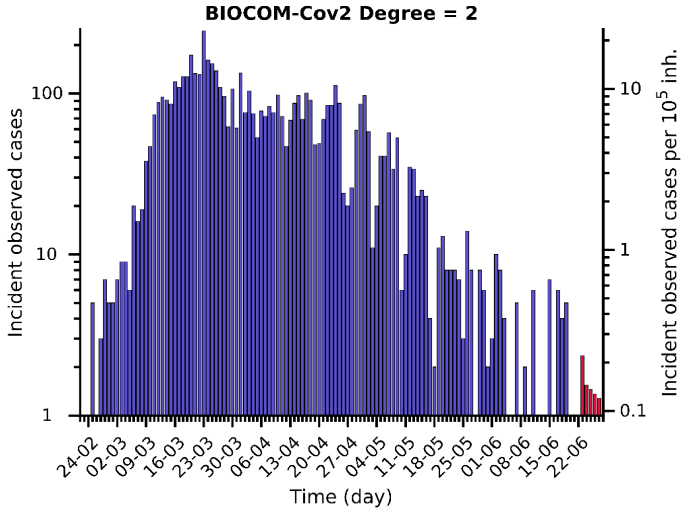


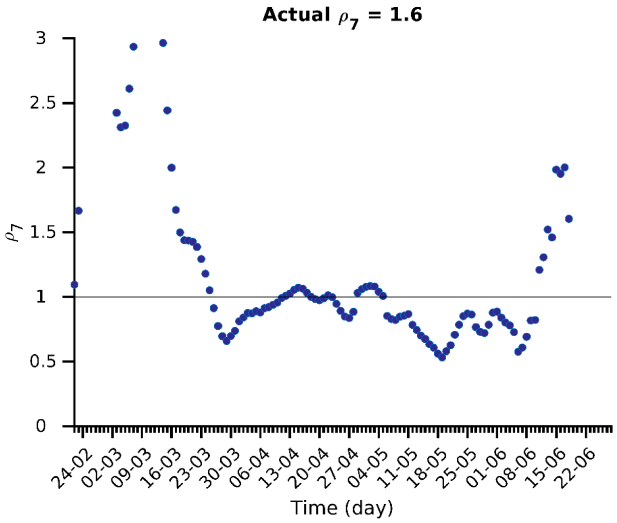
Extremadura 22-06-2020. Population: 1.1M. Current cumulative incidence: 530/10^5



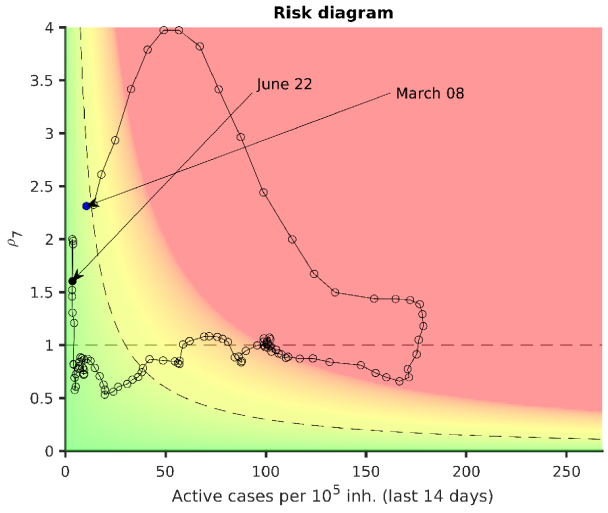
Deaths series currently under revision

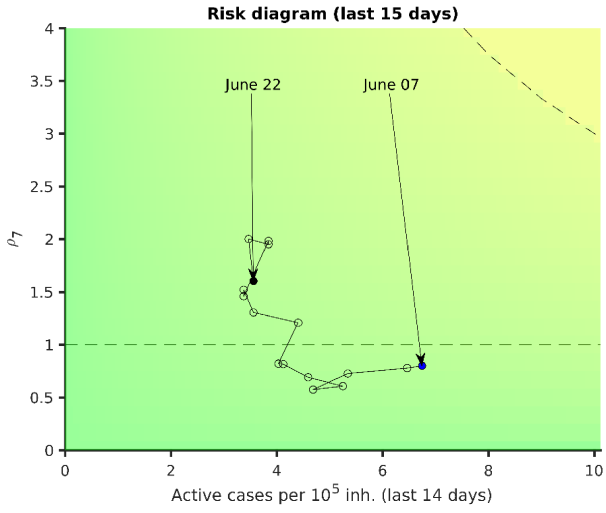




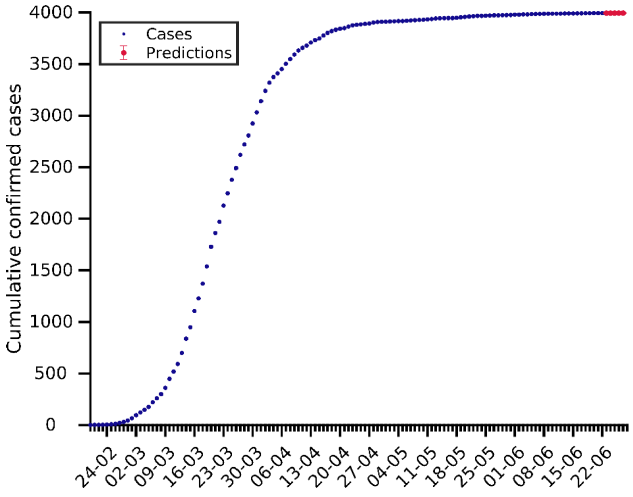


Deaths series currently under revision

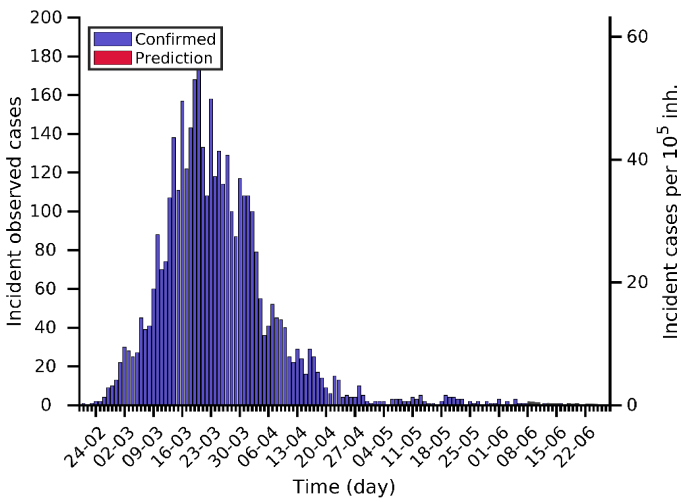


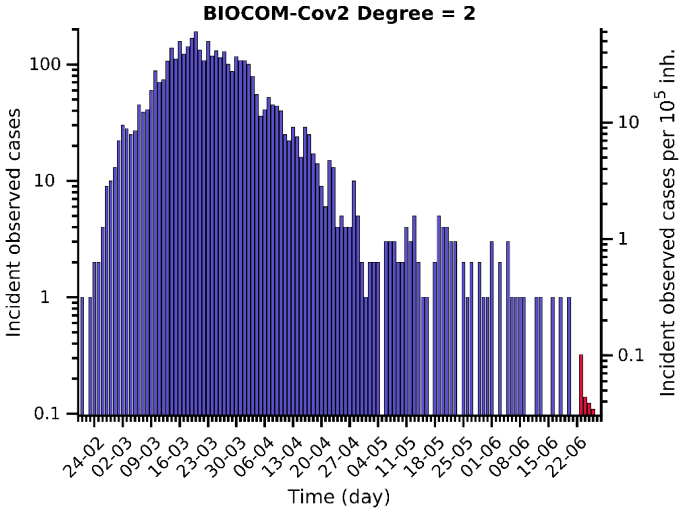


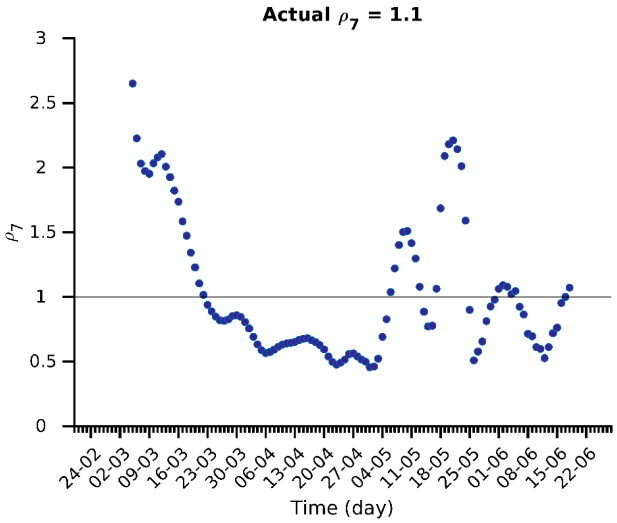
La Rioja 22-06-2020. Population: 0.3M. Current cumulative incidence: 1260/10⁵



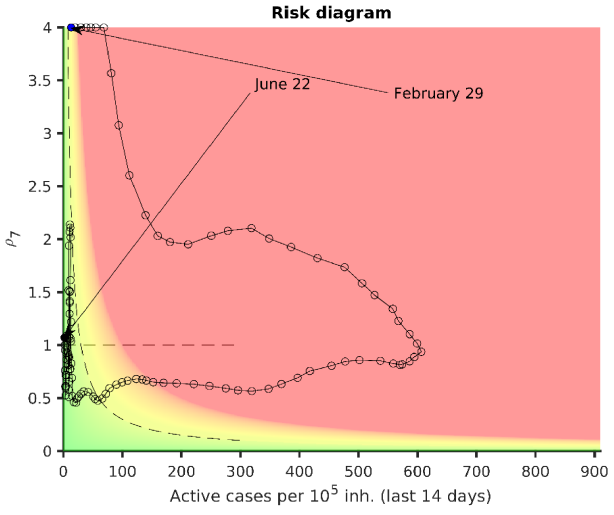
Deaths series currently under revision

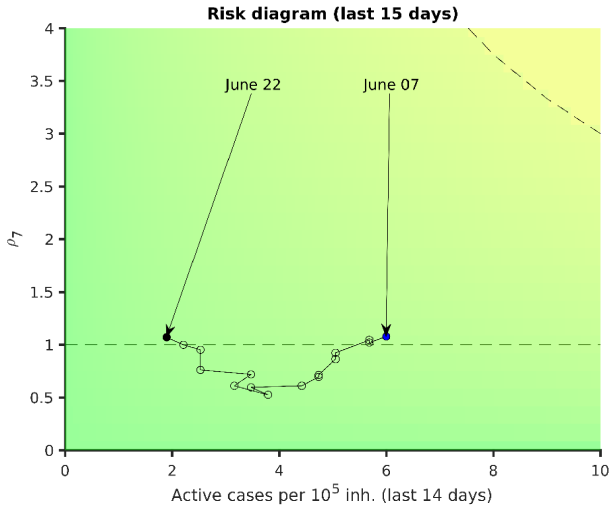




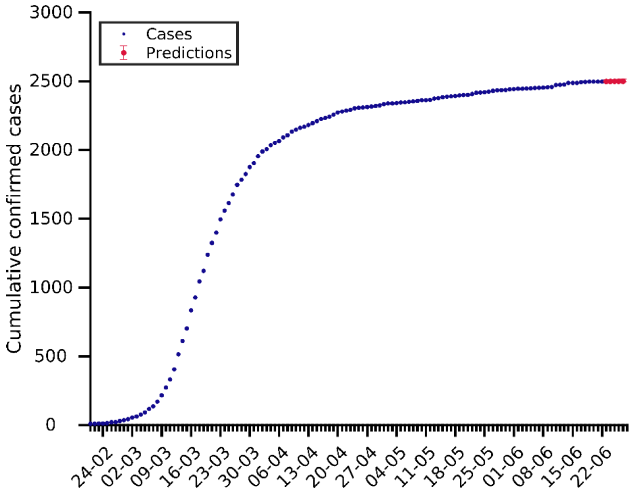


Deaths series currently under revision

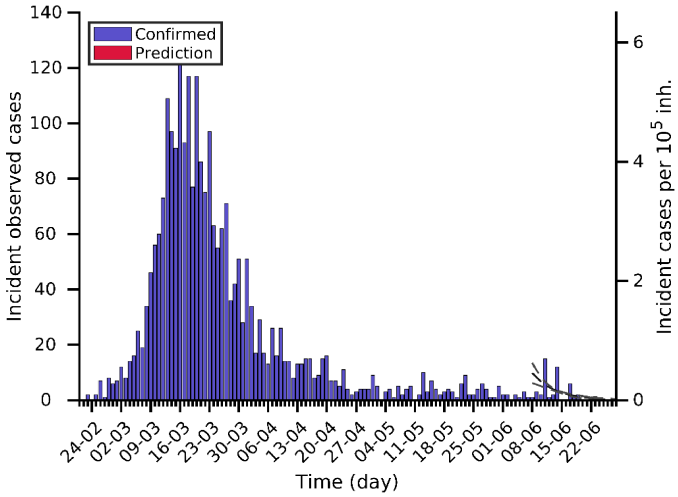


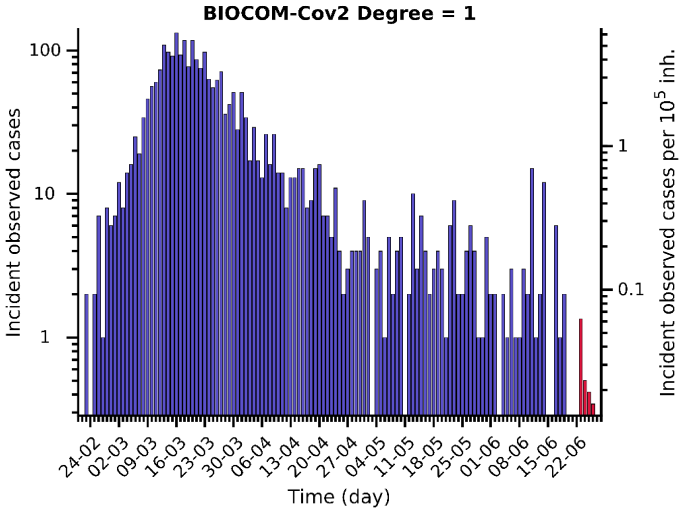


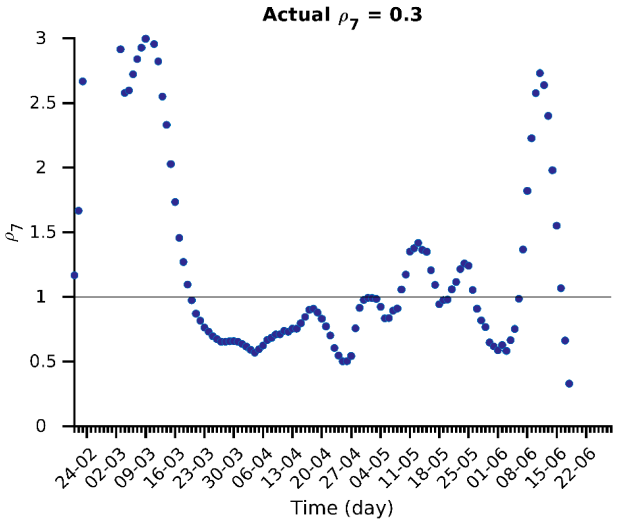
Canarias 22-06-2020. Population: 2.2M. Current cumulative incidence: 116/10⁵



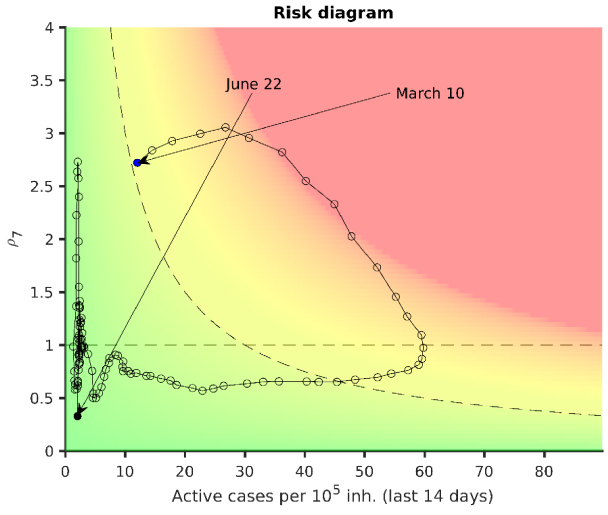
Deaths series currently under revision

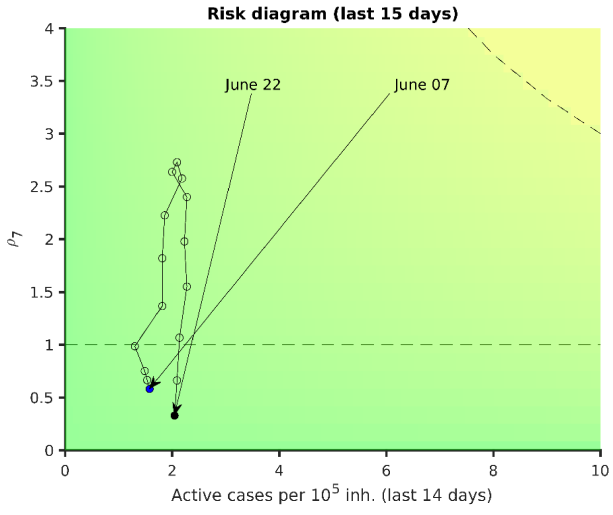




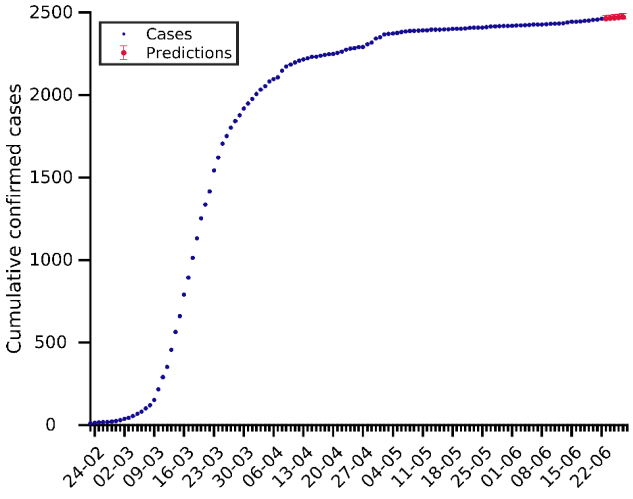


Deaths series currently under revision

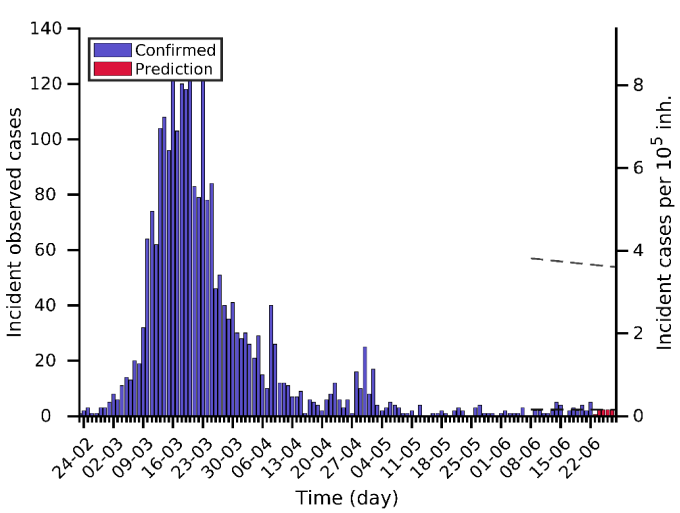


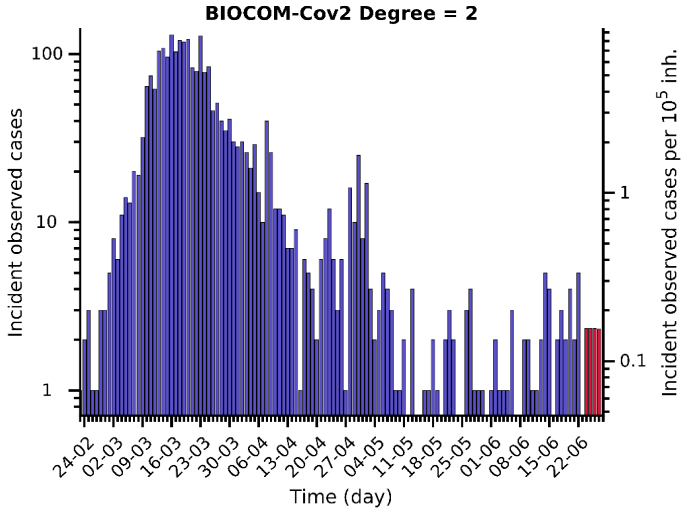


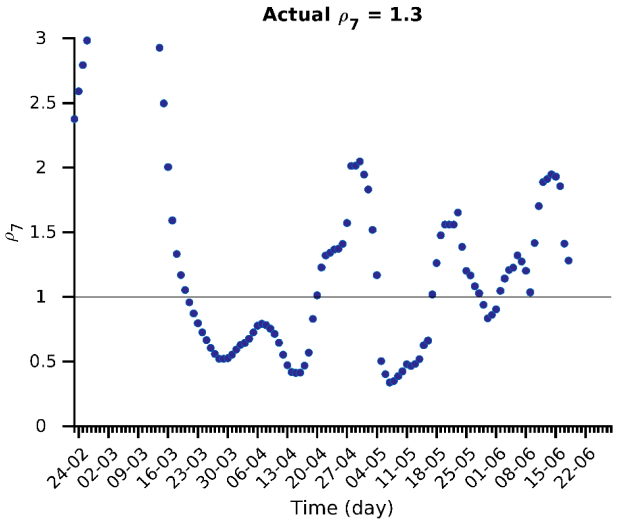
Murcia 22-06-2020. Population: 1.5M. Current cumulative incidence: $165/10^5$



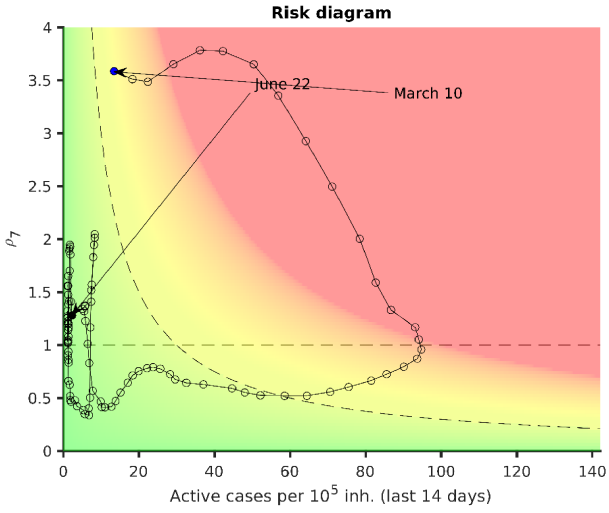
Deaths series currently under revision

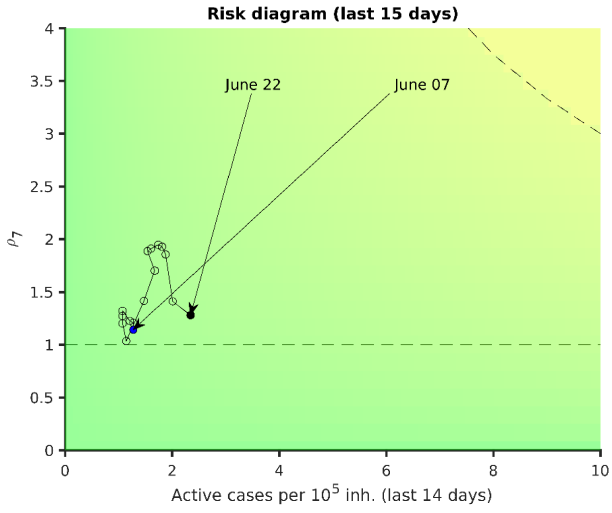




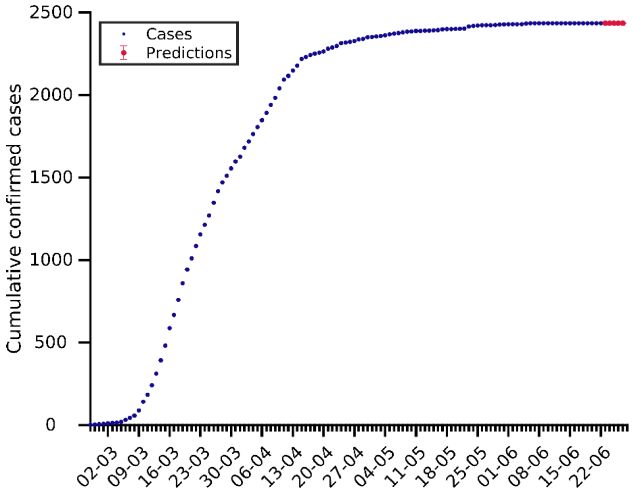


Deaths series currently under revision

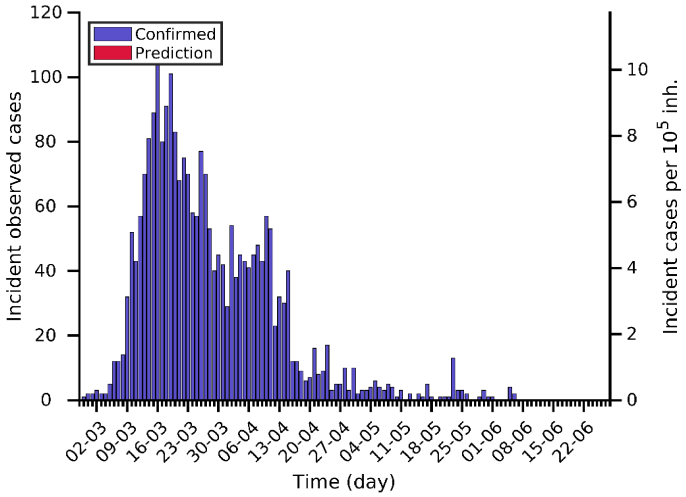


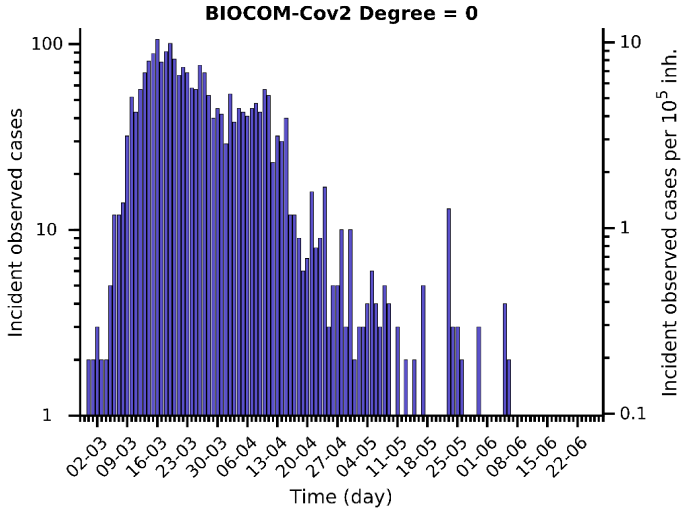


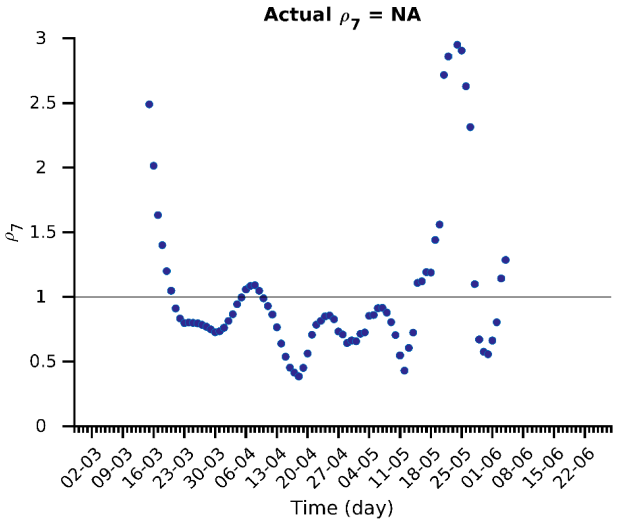
Asturias 22-06-2020. Population: 1.0M. Current cumulative incidence: 238/10⁵



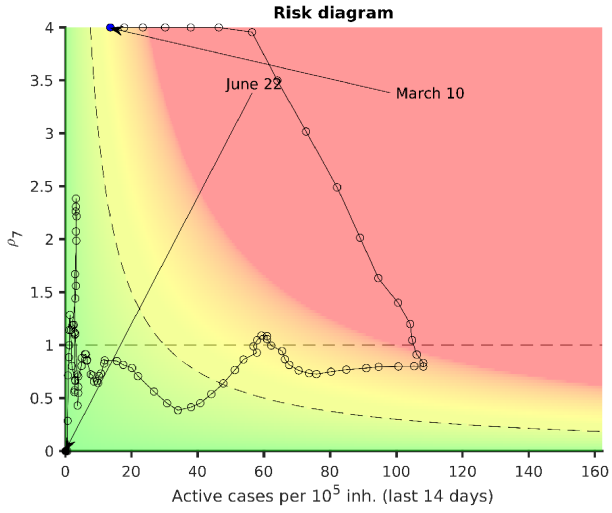
Deaths series currently under revision

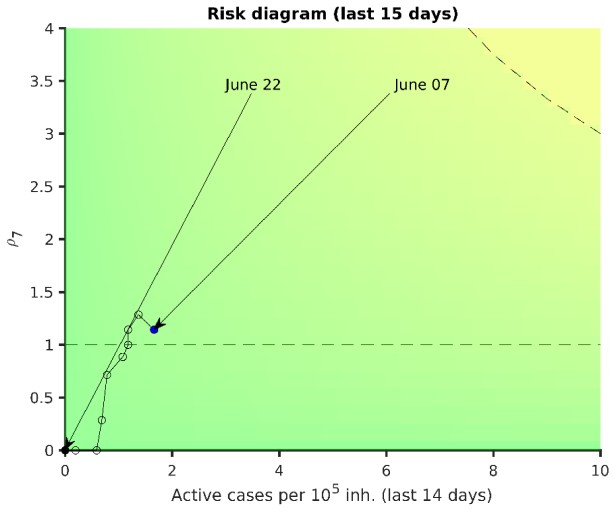




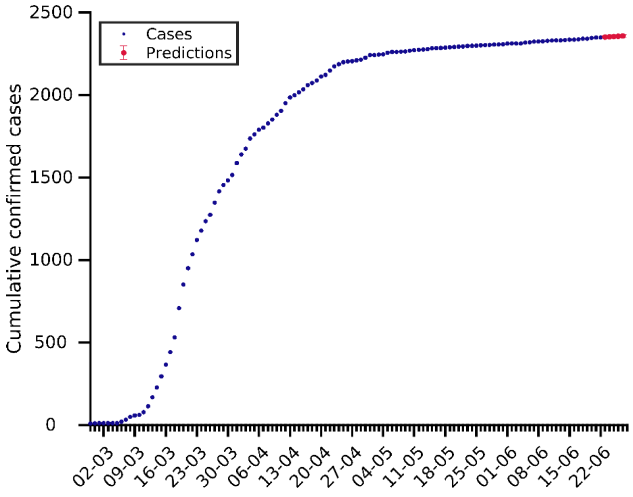


Deaths series currently under revision

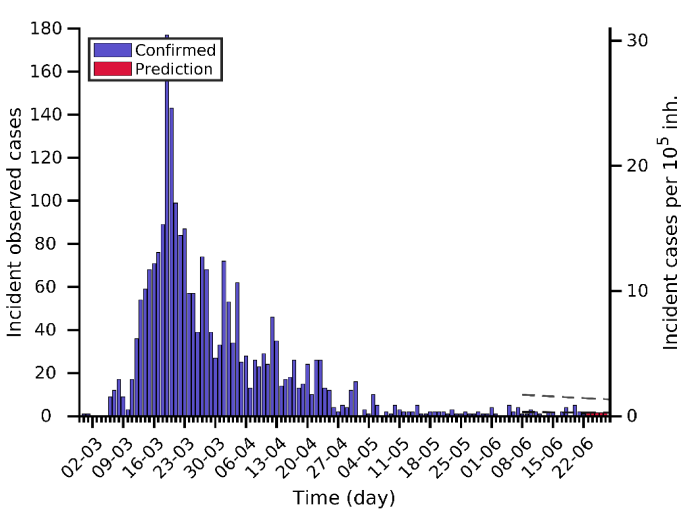


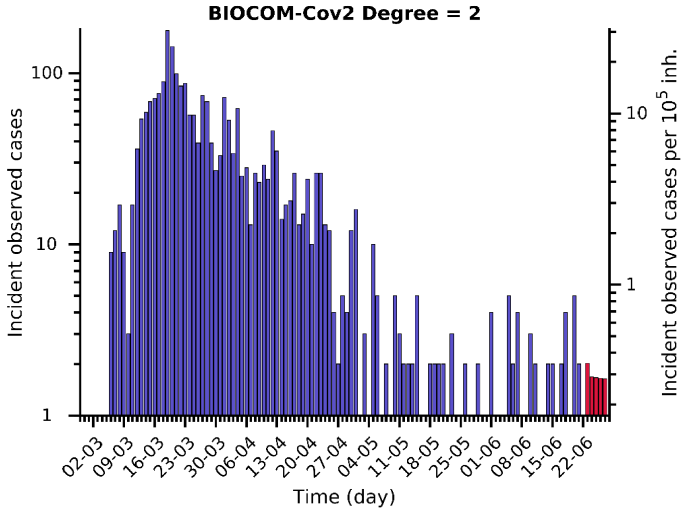


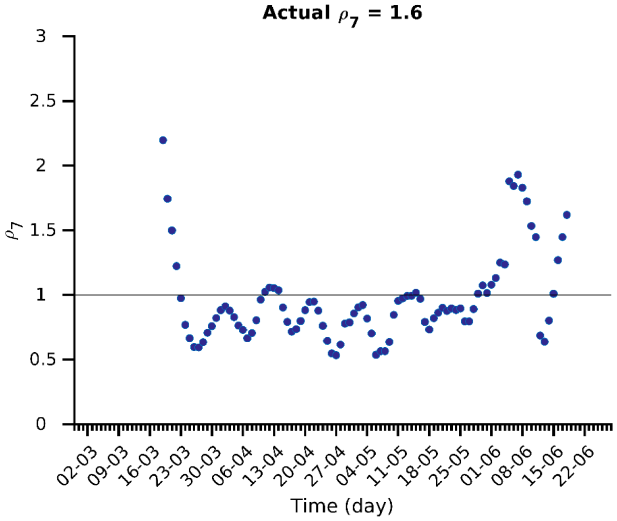
Cantabria 22-06-2020. Population: 0.6M. Current cumulative incidence: 404/10⁵



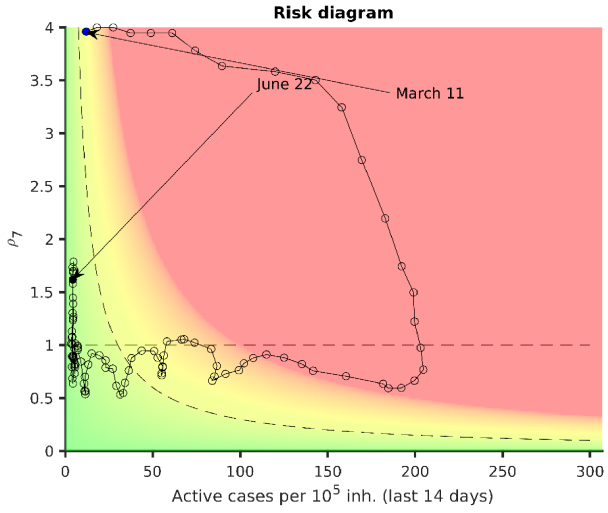
Deaths series currently under revision

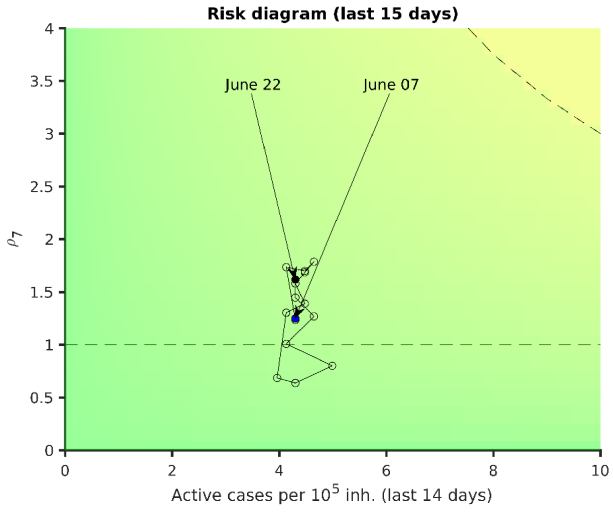




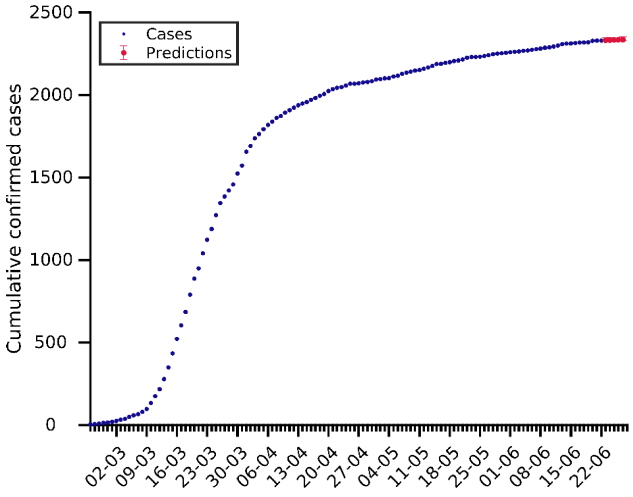


Deaths series currently under revision

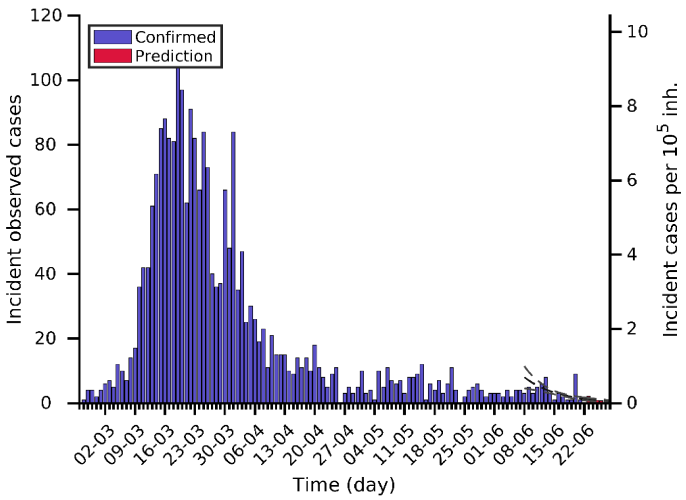


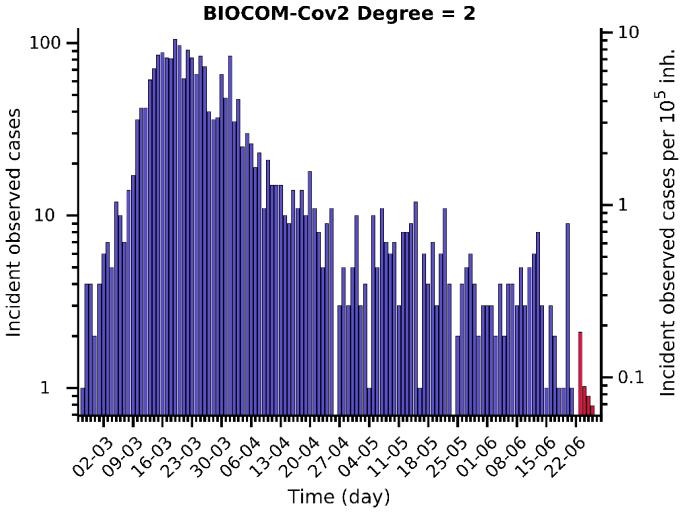


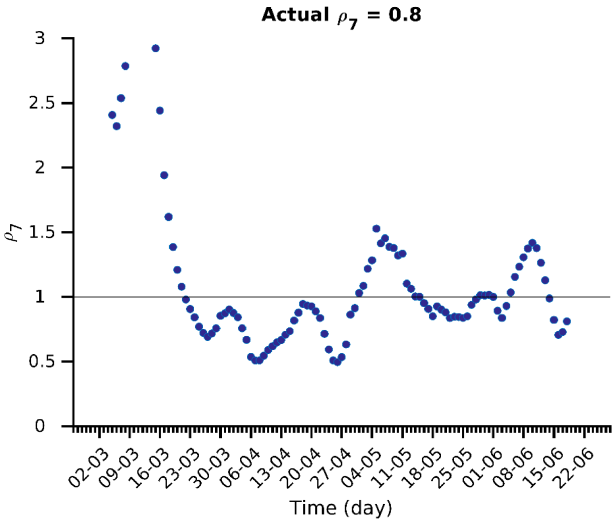
Baleares 22-06-2020. Population: 1.1M. Current cumulative incidence: 203/10⁵



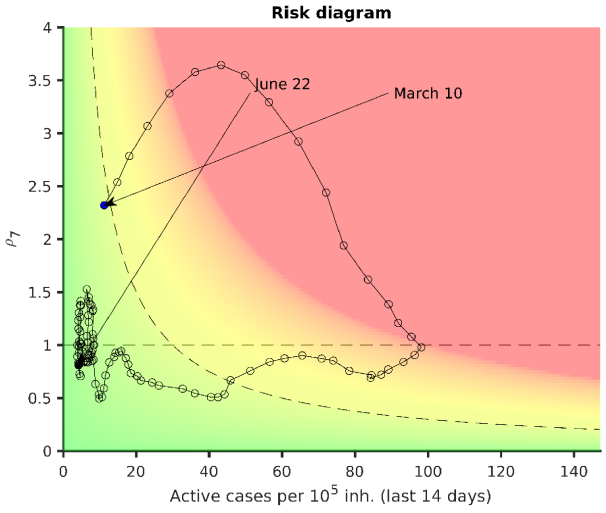
Deaths series currently under revision

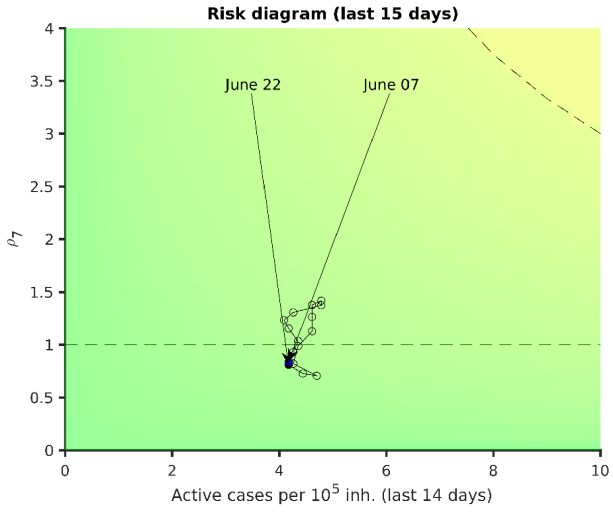




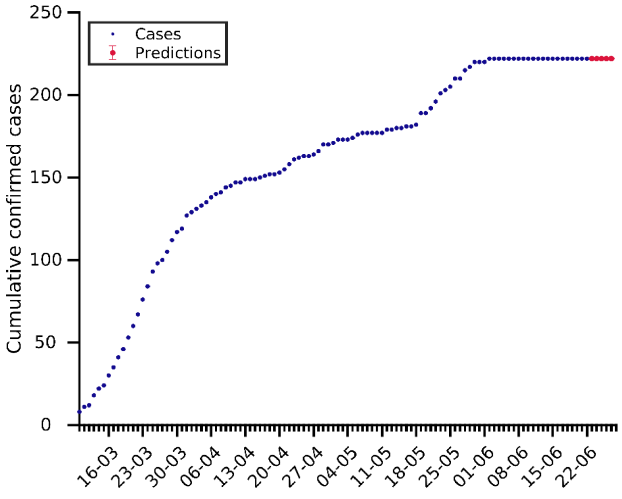


Deaths series currently under revision

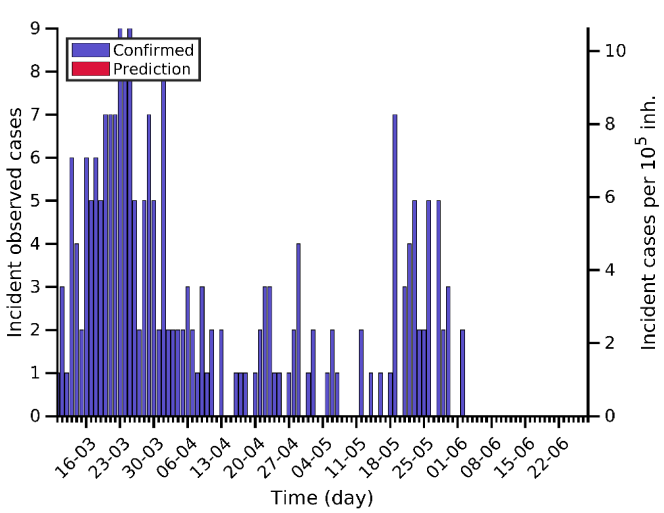


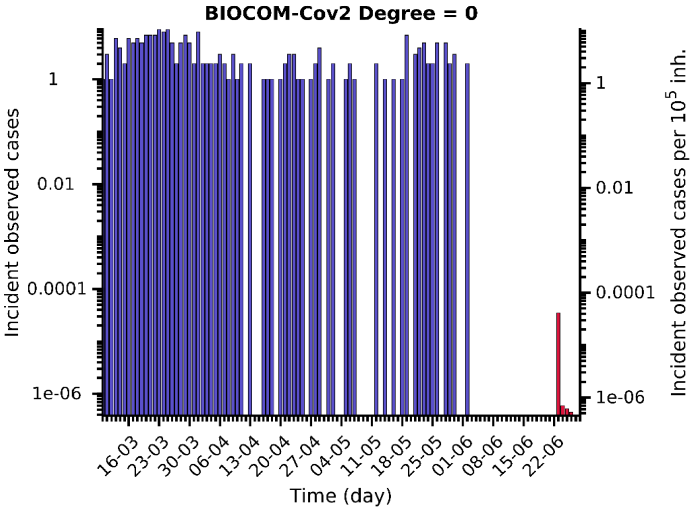


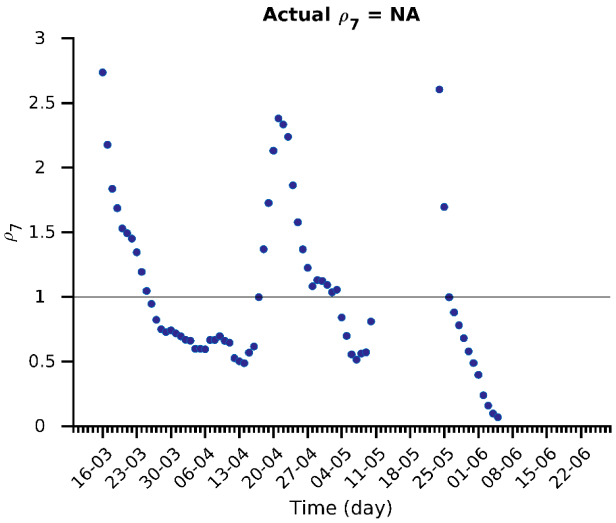
Ceuta 22-06-2020. Population: 0.1M. Current cumulative incidence: 262/10^5



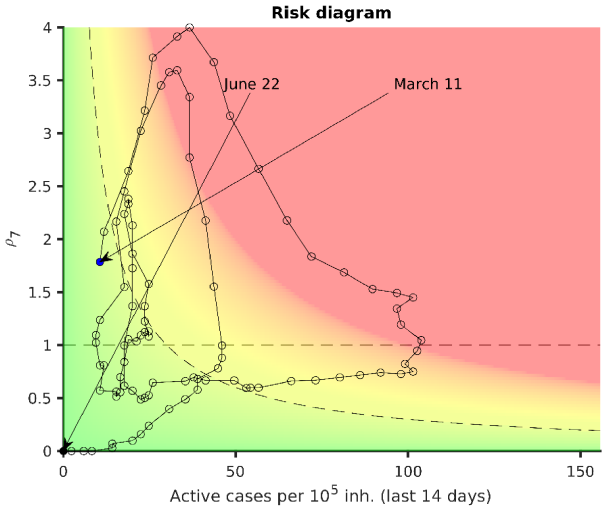
Deaths series currently under revision

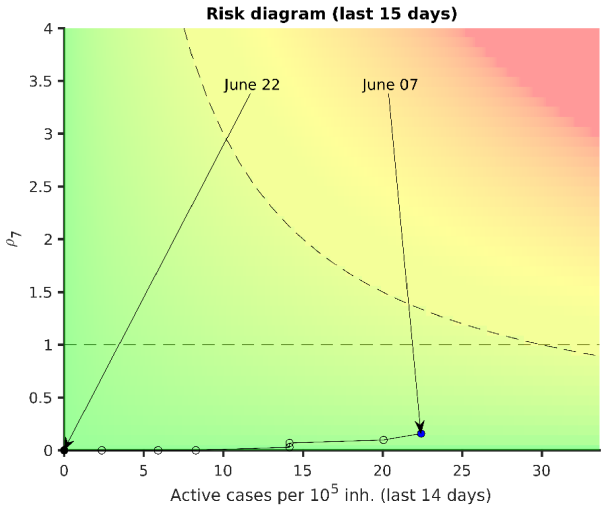






Deaths series currently under revision





Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports[3], from European Centre for Disease Prevention and Control (ECDC)[4] and from Ministerio de Sanidad[5]. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ: this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report (*t-1*):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t.

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

(I) an initial period where most of the cases are imported;
(II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

[3] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports
[4] https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases
[5] https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm https://github.com/datadista/datasets/tree/master/COVID%2019 , https://covid19.isciii.es/

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model[6] correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K\, e^{-ln\left(\frac{K}{N_0}\right)\cdot e^{-a\cdot(t-t_0)}}$$

where *N(t)* is the cumulated number of confirmed cases at *t* (in days), and N_0 is the number of cumulated cases the day at day t_0. The model has two parameters:

- ✓ *a* is the velocity at which specific spreading rate is slowing down;
- ✓ *K* is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which *N(t)* overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (*a* and *K*) and the R^2 of the fitting. At the initial stages the dynamics is exponential and *K* cannot be correctly evaluated. In fact, at this stage the most relevant parameter is *a*. Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted *a* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted *K* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a>0.2\ day^{-1}$, if $K>10^6$ or if the error in K overpasses 10^6.

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

[6] Madden LV. Quantification of disease progression. Protection Ecology 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days[7];
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors[8] in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

[7] At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

[8] Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3